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INSECT CONTROL IN SHELTERBELTS ON THE GREAT PLAINS

By

N. D. Wygant

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INSECT CONTROL IN SHELTERBELTS ON THE GREAT PLAINS

By

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In Cooperation With

U.S. FOREST SERVICE, Lincoln, Nebraska

September, 1936

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MEMORANDUM FOR.....Dr..Craighead.....

Enclosed are 2 copies of "Insect Control in Shelterbelts on the Great Plains." These are the only copies that can be spared. Last year I wrote to the Prairie States Forestry Project for additional copies but they had none and were unable to make additional copies. There are only 3 or 4 copies left at Fort Collins.

N.D. Wygant

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INTRODUCTION

The recent undertaking of the Shelterbelt Project in the Plains States by the Forest Service of the United States Department of Agriculture is resulting in the establishment of hundreds of miles of shelterbelt strips distributed from northern Texas to the Canadian line. An important consideration in the care of the trees on these strips is their protection from injurious forest insects. Successful control of insect pests often depends upon early recognition of the insect causing the damage and upon prompt application of control measures. This manual has been prepared to acquaint the field men with the various types of damage, and to furnish information that will assist in the recognition and control of the more important insects. Only the more common insects or those likely to be of economic importance have been discussed, although undoubtedly other species will be encountered. Unusual insect infestations or problems on shelterbelt strips should be brought to the attention of the Bureau of Entomology and Plant Quarantine so that investigations may be made.

There is need for considerable experimental work on the control of certain of the forest insects that have been discussed herein. The control measures listed, however, are the most effective methods known at the present time. When more detailed information is available on insects damaging shelterbelt plants, and experiments with control have been completed, it will be possible to revise and improve the present manual.

For convenience the insects most likely to damage trees on shelterbelt strips have been grouped according to their feeding habits under the following headings: Defoliating insects, boring insects, root-feeding insects, bark-girdling insects, and sap-feeding insects. These groups are subdivided as listed in the table of contents.

DEFOLIATING INSECTS

CATERPILLARS:

Caterpillars are the larvae or immature forms of butterflies and moths. They are generally cylindrical in shape, and the body is composed of thirteen segments besides the head. Each of the first three, or the thoracic, segments bears a pair of jointed legs terminating in a single claw. The abdominal segments bear typically five pairs of unjointed, fleshy projections called "prolegs," one pair each on the third, fourth, fifth, sixth, and tenth segments. With some species, such as the cankerworms, certain pairs of these prolegs are missing. The prolegs are armed with fine hooks, known as "crochets," which assist in gripping the leaf or branch. Since caterpillars have chewing mouth parts, the usual recommendation for the control of these pests is to apply a stomach poison, such as lead arsenate, to the foliage of the host. This poison is taken into the digestive tract with the food. One and a half pounds of lead arsenate to fifty gallons of water is usually recommended, although for more resistant species or large species that are nearly full grown, a somewhat heavier dosage, two to three pounds to fifty gallons of water, is required. A sticker such as fish oil or linseed oil, used at the rate of four ounces for each pound of lead arsenate, will make the poison adhere to the foliage for a longer time.

The species of caterpillars discussed in this paper are roughly divided into four groups: Naked caterpillars, hairy caterpillars, spiny caterpillars, and bagworms. This classification is merely an arbitrary one to assist in identification, and there is considerable overlapping within the groups. The naked caterpillars have a few hairs on the body, but these are inconspicuous. Placed in this group also are several large caterpillars with raised tubercles or projections on the body but lacking a hairy covering.

Naked Caterpillars

Fall Cankerworm (*Alsophila pometaria* Harr.)

Spring Cankerworm (*Paleacrita vernata* Peck)

The cankerworms belong to the family of loopers, also known as measuring worms, inchworms, or spanworms, and may be distinguished from other families of caterpillars by the presence of only two or three pairs of abdominal prolegs, in contrast to the five pairs on most caterpillars. While elm is the preferred host, many other species of trees are attacked. Defoliation takes place during May soon after the leaves come out.

There are two common species of cankerworms in this region, the fall cankerworm and the spring cankerworm. They commonly work together and it is often difficult to distinguish between them.

The wingless female adults of the fall cankerworm emerge from the soil during the warm days of fall following freezing weather (some may not emerge until spring) and crawl up the tree to lay their eggs in clusters on branches or trunk. The eggs remain on the trees over winter and hatch about the time the apple blossoms appear in May. After a month the caterpillars reach maturity and go into the soil, where they pupate in cocoons. There is one generation a year.

The female adults of the spring cankerworm, which are also wingless, do not emerge until early spring, during the first warm weather. Like the females of the fall cankerworm, they crawl up the trunks of trees and deposit their eggs in bark crevices. The eggs hatch and the larvae mature about the same time as in the case of the fall cankerworm. The caterpillars pupate in cells made in the soil but do not spin a cocoon. The pupae remain in these cells until the following spring, when the adults emerge.

The following table will serve to differentiate the two species in the various stages:

Stage	Fall Cankerworm	Spring Cankerworm
Egg	Eggs flowerpot-shaped and deposited in regular rows	Eggs oval and deposited in irregular mass
Larva	Three pairs of prolegs (first pair reduced); usually with a dark, broad line lengthwise on back	Two pairs of prolegs
Pupa	Spins silken cocoon	Spins no cocoon
Adult	Abdomen without spines	Abdominal segments with double transverse rows of reddish spines

The wingless female can be prevented from climbing the trees and depositing their eggs by placing sticky bands five to seven inches wide around the trees four or five feet above the ground. A commercial sticky tree-banding material, a home-made mixture consisting of five pounds of resin and three pints of castor oil, or a gypsy moth tree-banding material such as was developed at the Department of Agriculture's Gypsy Moth Laboratory, can be used. The substance should be spread on a strip of paper wrapped around the tree, and cotton batting or similar material placed in the cracks between the paper and the bark to prevent the insects from crawling under the barrier. The barriers should be installed in September or early October for control of the fall canker-

worm and in February for the control of the spring cankerworm. The bands should be inspected daily or weekly, depending upon the weather and the abundance of the insects, and all the females and the winged males that may have been attracted to them, as well as the leaves and other debris caught in the band, should be removed. A sticky surface should be maintained on the barriers during the period of emergence and migration of the young larvae.

Larvae feeding on the foliage can be controlled with a lead arsenate spray, 1½ to 2½ pounds to 50 gallons of water plus 6 to 10 ounches of linseed oil or fish oil.

Cecropia Moth
(Samia cecropia L.)

The cecropia moth is the largest native species of the giant silkworms. Although not considered to be of economic importance over most of its range, during the pioneer days it occurred on the Great Plains in sufficient numbers to make tree growing difficult. It is a general feeder, defoliating many species of trees and shrubs, and is widespread over the United States east of the Rocky Mountains.

The wings of the moths range in expanse from 5 to 7 inches. They are a dusky brown in color, with a white band bordered outwardly with red crossing the wings beyond the middle, a red spot near the apex of the fore wing, and a crescent-shaped spot bordered with red near the center of each wing. The moths are night fliers and are rarely seen in flight.

The mature caterpillars are light bluish green and from 3 to 4 inches long. The body is armed with six rows of raised tubercles and two additional short rows on the sides of the first five segments. The tubercles on the second and third segments are larger than the others, and coral red. The other dorsal and lateral tubercles are yellow, except those on the prothorax and the last abdominal segments, which are blue. All tubercles are armed with black bristles.

The first larval stage is black, the second orange, the third yellowish green, and the last bluish green. All stages have the conspicuous tubercles.

The winter is passed in the pupal stage inside large, tough, thick, brown elongate cocoons attached to twigs or shrubs. The moths emerge soon after the leaves appear, in May or June in Nebraska. The moths soon mate and lay their eggs in small groups on the leaves of the host, and the eggs hatch in six to ten days. The larvae mature during the summer and spin their cocoons and pupate. There is one generation a year.

Ordinarily the larvae are heavily parasitized and are thus prevented from becoming numerous. The cocoons are easily collected

during the winter, when the leaves are not on the trees or shrubs. The larvae can be poisoned when small with the usual dosages of lead arsenate, but when large, the heavier dosage should be used (see page 2.)

Polyphemus Moth
(Telea polyphemus Cram.)

This insect often attracts attention because of its large size, but it is rarely abundant enough to cause serious damage. The larvae feed upon maple, boxelder, oak, walnut, elm, apple, plus, chokecherry, sand cherry, honey locust, black locust, willow, and many other trees.

The adult is a beautiful, large, yellowish or brownish moth with a wing spread of four to five inches. There is a transparent windowlike spot in each wing encircled by yellow and black rings, with the black ring on the hind wing much widened, especially toward the base. The moths are night fliers and rarely seen.

The caterpillar when mature is three or more inches long, and has seven oblique pale-yellow lines on each side, one on each segment except the first and last. Each segment has six small orange-colored tubercles. The spiracles, along the sides, are pale orange.

The pupae overwinter in large, oval, tough silk cocoons, usually wrapped in a leaf on the ground or attached to a branch. The moths emerge in the spring and lay their suboval, somewhat flattened eggs on the leaves of the host during June. The caterpillars mature and spin their cocoons the latter part of the summer. There is one generation a season.

The caterpillars can be hand-picked on small trees, but when numerous lead arsenate should be applied while the larvae are small. For dosages of lead arsenate to use see page 2.

Green-Striped Maple Worm
(Anisota rubicunda Fab.)

At times, and in some localities, the green-striped maple worm appears in such abundance as to completely defoliate all soft maples and some hard maples, boxelders, and oaks, where they are near the soft maples.

The moth is pale yellow shaded with pink, but some forms are nearly white with very little pink. The female has a wing spread of nearly two inches and her body is woolly in appearance. The male is somewhat smaller but similar in appearance. The egg is about 1/25 inch in diameter, slightly flattened, and pale gree, becoming yellowish before the larva hatches.

The larvae are hairless, pale yellow, and striped longitudinally with dark green. Back of the head, on the second thoracic segment, is a pair of long black horns, and on each side and at the posterior end of the body are a number of short, black, spinelike projections. The larvae are nearly two inches long when full grown.

The winter is passed as a pupa in the ground. In May or June, depending on the locality, the moths emerge and lay their eggs in groups on the leaves. In about ten days the larvae appear, and after a month they become full grown and enter the soil to pupate. Two weeks later the moths emerge to lay eggs for the second generation. In the Northern States there may be one or two generations annually, while in the Southern States there may be three.

The caterpillars are easily controlled, especially when young, with lead arsenate spray, mixed at the rate of 1½ to 2 pounds to 50 gallons of water.

Hawk Moths or Hornworms

The larvae of the hawk moths or sphinx moths, generally known as hornworms, are common defoliators of trees in the Great Plains. Many are general feeders upon various species of plants. During the summer of 1935 ash was defoliated in parts of northern Nebraska, and South and North Dakota, probably by the white-lined sphinx (Celerio lineata Fab.) The poplar sphinx (Pachysphinx modesta Harris) is found on cottonwood and other poplars and occasionally on willows.

The moths are stout-bodied insects with wings long, narrow, and very strong. They are very graceful and easily recognized. In general they are night fliers, but they may be found at twilight or on cool days hovering over flowers as do hummingbirds.

The smooth-skinned, naked caterpillars are easily recognized by the horn on the dorsal side of the eighth abdominal segment, near the anal end of the body. When not feeding they often rear the front end of the bodies in the air and curl their heads down. The larvae of some species are large, attaining a length of three or more inches when mature.

A general life cycle for this family is as follows: The winter is passed as pupae in the soil. In the spring the moths emerge and lay their eggs on the host. The larvae hatch and when mature go into the soil or under debris to pupate. There is one to several generations a year, depending upon specific habits and the latitude.

On shade trees the caterpillars can be hand-picked, but when numerous on shelterbelts a lead arsenate spray of 1½ to 2 pounds to 50 gallons of water plus 6 to 8 ounces of linseed or fish oil will control the young larvae.

Alfalfa Caterpillar
(Eurymus eurytheme Bdv.)

This insect is particularly a pest of alfalfa, but during the summer of 1935 it was also observed defoliating Caragana in South Dakota. The caterpillars were common here from the first of July to the middle of September.

The caterpillars are smooth-skinned, grass green in color, with a white stripe running lengthwise on each side of the body, through which runs a very narrow red line. When mature the larvae are nearly 1½ inches in length.

During the summer the sulphur-yellow butterflies (some may be nearly white), with a wing expanse of 1½ to 2 inches, are prevalent flying over alfalfa fields. The margins of the wings are black with very narrow yellowish-pink outer margins. Near the center of the fore margin of the front wings is a black spot approximately 1/16 inch in diameter. In a comparable position on the hind wing is a somewhat larger orange spot.

The insect passes the winter as a naked chrysalis or pupa on plants, except in the extreme Southern States, where it may be found in all stages during the winter months.

In the spring the butterflies lay their eggs on the leaves, and the eggs hatch in a few days. Approximately two weeks after hatching the larvae are full grown. The caterpillars change to the pupal stage on the host plant without spinning a cocoon. The anal end of the chrysalis is attached to the stalk, and a loop of silk thrown around the body a little above the middle holds it upright. The butterflies emerge five to seven days after pupation. In the southwestern States there are from five to seven generations a year, and probably at least two occur in the northern part of the insect's range.

An arsenical spray will poison the caterpillars, but there is always danger of the Caragana being reinfested by the butterflies emerging from the alfalfa fields. Control of this insect in the alfalfa fields consists of cutting them clean so that there is not sufficient leaf growth to support the caterpillars to maturity, pasturing where possible, discing in the fall to kill overwintering pupae, and eliminating volunteer host plants around the fields which serve as breeding places.

Hairy Caterpillars:

Cottonwood Dagger Moth
(Acronicta populi Riley)

The caterpillars of the cottonwood dagger moth may completely defoliate young cottonwood and willow trees. The larva is yellowish

green and covered with numerous soft, bright yellow hairs. Some of the body segments bear long tufts of black hairs on the top. Generally there are five of these tufts, but the number varies from three to six. The head is shiny black with a white inverted V on the front. During the day the caterpillars lie curled up on the underside of the leaves. When full grown, having a length of approximately 1½ inches, they crawl into debris or cracks and spin silken cocoons intermixed with hairs from their body and change to the pupal stage.

The moths are night fliers of the family Noctuidae. Their wings are white and finely peppered with tiny dark spots, which gives them a pale gray appearance. They are marked with a series of small black spots on the fringes, one spot between each vein or nerve. There are also larger spots on other portions of the front wings.

In Nebraska there are two generations a year, the caterpillars from the first generation appearing in June, and those from the second generation in September or October.

For control, the foliage may be sprayed with lead arsenate at 1½ to 2 pounds to 50 gallons of water and 6 to 8 ounches of fish or linseed oil.

Eastern Tent Caterpillar
(Malacosoma americana Fab.)

This insect attacks cherry, including chokecherry and sand cherry, apple, plum, peach, and rarely willow, poplar, oak, and other forest trees. In some years the insect is abundant and causes considerable defoliation, in other years it is scarce.

The moths are dull reddish brown with two light oblique parallel lines on the front wings. The wing spread of the female is 1½ to 2 inches. That of the male is somewhat less.

The caterpillars are nearly black, with a white longitudinal dorsal line, and dots of blue and white along the side. The bodies are sparsely clothed with long, soft, yellowish hairs. The caterpillars are nearly two inches long when mature.

The winter is passed in the egg stage on twigs. Soon after the buds burst in the spring, the eggs hatch and the larvae begin feeding on the new foliage. They make a tent of silk in the crotch of a branch, and from this tent they wander out on the branches for food. After four to six weeks, when the caterpillars reach maturity, they leave the tent and spin their cocoons in bark crevices, in the grass, or similar places, where they change to the pupal stage. The cocoons are covered with a yellow sulphurlike powder. In about three weeks after pupation the moths emerge and lay their eggs in a mass that completely encircles the twig. There is one generation a year.

This insect can be controlled by collecting and destroying the overwintering eggs, destroying the caterpillars when they are at rest in the tents, or with an application of a lead arsenate spray, 1½ pounds of lead arsenate, 50 gallons of water, and 6 ounces of linseed oil or fish oil.

Forest Tent Caterpillar
(Malacosoma disstria Hbn.)

The forest tent caterpillar is common throughout North America, and is a general feeder on many species of forest, shade, and fruit trees. In certain years it causes serious defoliation, but it is generally held down by its natural enemies and other difficulties.

The moths are similar in size, shape, and color to those of the eastern tent caterpillar, but can be distinguished from them by the two oblique parallel lines on the fore wings, which are darker than the wings. The comparable lines on the wings of the eastern tent caterpillar are lighter than the background.

The mature caterpillars, which are nearly two inches long, vary in color from bluish gray to bluish black. Thdy are similar to the larvae of the eastern tent caterpillar, but can be distinguished by the row of diamond-shaped or oval white spots down the back. The eastern tent caterpillar has an unbroken line down the back.

The eggs are laid in masses, each containing from 100 to 400 eggs, encircling the twigs and covered with a brownish material. The ends of the masses are abruptly cut off, thus differing from the egg masses of the eastern tent caterpillar, which are more oval in outline and have sloping edges.

The winter is passed in the egg stage. With the first warm weather in spring, often before the buds burst, the eggs hatch, and with the opening of the foliage the larvae begin feeding. The larvae do not spin a silken tent, as the name implies, but are gregarious during the early stages, frequently congregating in large groups to rest or molt. During the later stages they feed and wander separately. In about six weeks the larvae are full grown and spin their cocoons, which are covered with a sulphurlike dust, on leaves, bark, fence posts, rocks, etc. The moths emerge and lay their eggs during June and July. The larva forms inside the egg during the summer, but does not hatch until the following spring.

Collecting the egg masses or destroying the congregated larvae will aid in control, but a lead arsenate spray, 1½ to 2 pounds to 50 gallons of water, plus 6 to 8 ounches of linseed or fish oil, is most effective. It should be applied while the caterpillars are small.

Fall Webworm
(Hyphantria cunea Drury)

The fall webworm is widely distributed over the United States and Canada, and is recorded from a large number of hosts, including forest, shade, and fruit trees. Cotton wood and boxelder are often heavily infested in the Plains States. The dirty white webs or tents in which the caterpillars feed are conspicuous on the trees during the summer and early fall.

The moth is clothed with soft hairs, has a wing expanse of 1½ to 1 3/4 inches, and varies in coloration from pure white to white with brown or black spots. The bases of the front legs are orange or bright red.

When first hatched, the small caterpillars are pale yellow with black heads and two rows of black marks along the body. The full grown larvae are about one inch long and appear pale yellowish or greenish, with a broad dusky stripe down the back and a yellow one along each side. They are covered with rather long whitish, yellowish, or brownish hairs, which arise from a series of black and orange-yellow tubercles. The larvae vary greatly in depth of coloring and in their markings.

The eggs are globular, yellowish, and adorned with regular pits. They are laid on leaves in masses of 400 to 500 interspersed with hairlike scales. In one to two weeks, depending upon the weather, the eggs hatch and the larvae from one egg mass spin a web of silk enclosing the caterpillars and some foliage. As the larvae grow they increase the size of their web to enclose more foliage. No feeding is done outside of this shelter. This web, enclosing one to several branches, is very conspicuous and unsightly owing to the excrement, cast larval skins, and brown foliage that collects within. In about a month the caterpillars are mature and they wander from their web (some may remain in the old web) in search of protected places to pupate, such as in debris or bark crevices. The larvae of the fall generation may go a short distance into the soil to pupate. In northern Nebraska and in South and North Dakota there is one generation a season, but farther south there are two or more generations a year.

The date of the emergence of the moth from the overwintering pupa varies from May to July, according to the locality. The webs are most common during August and September.

When the web enclosing the young larvae is small, the branch can be cut and destroyed. When such measures are not possible, a thorough spraying with lead arsenate around the webby nests while the caterpillars are small -- so that this foliage will be enclosed and eaten as the nest is extended -- is an effective method of control.

Walnut Caterpillar
(Datana integerrima G. and R.)

Walnut trees growing in the open as shade trees are most subject to defoliation by this insect. Black walnut is the preferred host, but

butternut, pecan, hickory, and possibly other species are also attacked.

The newly hatched larvae have black heads and faintly striped brickred bodies. As the larvae grow their bodies become darker and the lines more distinct, but when full grown the lines are again indistinct and their bodies black, covered with long, dirty gray, frowzy hair. The mature caterpillars are slightly more than two inches long.

The fore wings of the moth are buff brown with four irregular darker transverse lines. The hind wings are lighter in color and have no markings. The adult has a heavy body and a wing spread of nearly two inches.

In the northern Shelterbelt States the moths emerge in July, but in the Southern States they appear considerably earlier. A few days after emergence eggs are deposited in masses of several hundred on the undersides of the leaves. In eight to ten days the eggs hatch and the larvae begin feeding on the undersurface of the leaves, but soon devour entire leaves. The larvae feed gregariously until the last few days of development, when they separate and wander. At molting time the larvae from one group assemble at one spot, usually on the trunk of the tree, and there shed their skins. This hairy compact mass of cast skins held together with silk threads remains attached to the tree for some time. When the larvae are disturbed, they suddenly elevate both ends of their bodies in a threatening attitude. The caterpillars are present during July, August, and part of September. In the Northern States there is only one generation a year, while probably two occur in the South. When mature the larvae enter the soil and pass the winter in the pupal stage.

When the caterpillars congregate to molt, they can be destroyed by crushing, or they can be poisoned on the foliage in their younger stages with lead arsenate at the rate of 1½ to 2 pounds to 50 gallons of water plus 6 to 8 ounces of linseed oil or fish oil.

Yellow-Necked Caterpillar
(Datana ministra Drury)

This insect prefers fruit-tree foliage, but when abundant it will readily defoliate many species of shade and forest trees. As with the walnut caterpillar, the larvae feed in groups, and when plentiful they may completely defoliate the small trees.

The mature larva is nearly two inches long, black with yellow stripes extending lengthwise, and sparsely covered with whitish hairs. The caterpillar obtains its name from its yellow thoracic shield (upper part of the neck).

The adult is similar to that of the walnut caterpillar.

In the vicinity of Ohio, and probably also in the central Shelterbelt States, the adults emerge by early summer and lay their oval white eggs in masses on the undersides of leaves. By late summer the larvae are mature and enter the soil to pupate and pass the winter.

Control measures are the same as those used against the walnut caterpillar.

White-Marked Tussock Moth
(Hemerocampa leucostigma S. and A.)

The white-marked tussock moth is widespread over the eastern half of the United States. It is commonly a pest of city shade trees and may not be serious in the shelterbelt strips. It prefers poplar, elm, linden, soft maple, and horsechestnut, but will feed on nearly all kinds of deciduous fruit, shade, and forest trees.

The mature caterpillar is 1½ to 1 3/4 inches in length, with a red head and a black stripe down the middle of the back bordered on each side with a yellow line. It has two long pencils of black hairs on the anterior end and one on the posterior end, and a white tussock of hairs on the dorsal side of each of the first four segments of the abdomen. The color and appearance of the larvae differ after each molt; consequently, caterpillars of different ages may be mistaken for separate species.

The female moth is wingless or nearly so, and is grayish, hairy, and grublike in form. The male moths are winged, brownish, and marked with shades of gray and cross lines near the outer margins.

The overwintering eggs hatch in May, and the larvae skeletonize and later devour the leaves. In five to six weeks the caterpillars are mature, and they crawl to a crack in the bark, a crevice in a wall, or any sheltered spot, where they spin a loose cocoon mixed with hairs from the body, and pupate. The moths emerge ten to fifteen days after pupation. Mating takes place near the old female cocoon. The female lays from fifty to several hundred eggs mixed with a white frothy mass, usually on the cocoon from which she emerged.

In the northern part of its range there is only one generation a year, while farther south there may be two, three, or more.

The overwintering egg masses can be collected or they can be destroyed by painting with creosote, but usually many are undetected and these measures are not entirely effective. Since many eggs are laid in the higher parts of the trees, the sticky-band barriers as used against the fall and spring cankerworms are also ineffective. Lead arsenate applied to the foliage during the early larval stages is the best means of control. For dosages of lead arsenate to use, see page 2.

Spiny Caterpillars

Mourning-Cloak Butterfly or Spiny Elm Caterpillar (Hamadryas antiopa L.)

This insect is widely distributed over the temperate regions of North America, Europe, and Asia. It is occasionally a pest of elm, willow, poplar, and hackberry in the Great Plains.

The adult has velvety, dark purple, nearly balck wings, with a white to yellow border on the outer margin. Inside of this border is a row of light purple spots. The wing spread is $2\frac{1}{2}$ to $3\frac{1}{2}$ inches.

The mature caterpillar is 2 inches long, with a ground color of black sprinkled with small white dots, giving the insect a grayish appearance. Down the middle of the back is a row of red dots, and on each body segment is a transverse row of branched black spines.

During the winter the butterflies hide under rocks, under loose bark, in hollow trees, and in other protected places. They are commonly seen flying about during the first warm days of spring. They lay their eggs in a band around a small branch during May. The eggs hatch in twelve to fifteen days and the larvae feed gregariously, several larvae often lining up on the same leaf with their heads together eating on the margin. The larvae change to the chrysalis or pupal stage with the anal end attached to a branch, and have no cocoon. There are apparently one to several generations a year.

The branches upon which the groups of caterpillars are feeding can be cut and the caterpillars destroyed, or the infested branches can be sprayed with lead arsenate when the caterpillars are small, at the rate of $1\frac{1}{2}$ to 2 pounds to 50 gallons of water plus 6 to 8 ounces of linseed or fish oil.

Painted Lady (Cynthia cardui L.)

The painted lady is widely distributed over all temperate and some tropical regions of the world. The caterpillars feed ordinarily on thistle and other weeds, but during the summer of 1935 they were observed feeding on young trees, especially elm, in the shelterbelt strips and nurseries. They may or may not prove to be serious pests of shelterbelt trees.

The butterfly has a wing spread of about two to three inches. The basal portions of the wings are brown, the middle red, and the tips of the fore wings black with white spots. The hind wings are orange-brown with black spots. The undersides are marble gray, buff,

and white, the fore wings red near the middle, and the hind wings have a row of four distinct eye spots with blue centers. The chrysalids are iridescent brown or gold.

The caterpillars are about 1½ to 2 inches long, dull brown or black, and covered with branched and unbranched spines.

The adults appear in the spring and are common throughout the summer. Mature caterpillars were collected on American elm at North Platte, Nebraska, early in October. They web or loosely tie a leaf on the upper side so that it is curled up in the shape of a U. The caterpillar feeds inside this protection, until only the coarser leaf veins and occasionally ragged, uneaten portions of leaves remain.

Lead arsenate would no doubt be effective against these caterpillars.

Bagworms

Bagworm
(Thyridopteryx ephemeraeformis Haw.)

The bagworm is injurious on the Great Plains from Kansas southward, attacking many species of trees including both hardwoods and conifers. Severe defoliation is more injurious to conifers than to the hardwoods, since the latter are capable of putting out new leaves.

The adult female is a wingless moth resembling a larva. The male moth has a black furry body with feathery antennae, and with wings thinly covered with scales which easily rub off leaving them transparent. The wing spread is about one inch.

The caterpillars live in spindle-shaped bags constructed of silk and bits of leaves and twigs and have a dark leaden color.

The winter is passed in the egg stage within the bag of the female. In the spring the eggs hatch, the larvae crawl out, and each one immediately makes a silken bag for itself. The larva extends its head and legs out of the bag to feed and move about. As it grows it enlarges the bag until it finally becomes one to two inches long. Late in the summer the mature larvae attach the upper end of these bags to the branches with silk and change to the pupal stage. The pupal period lasts several weeks. Then the male moths emerge and seek the wingless females. After mating the female deposits her eggs and dies.

These bags are conspicuous during the winter months, especially on the deciduous trees. Small infestations can be controlled by hand

picking them at this time. The caterpillars have been recorded as somewhat resistant to arsenicals; therefore, a heavier dosage of lead arsenate should be applied than is recommended for most insects, 2 to 2½ pounds to 50 gallons of water plus 8 to 10 ounces of fish oil or linseed oil, and good coverage of the infested plants with the spray should be obtained. Application should be made when the bagworms are young.

SAWFLY LARVAE

Sawfly larvae are the immature forms of four-winged, wasplike flies (Hymenoptera), and superficially resemble the caterpillars. The typical sawfly larvae has seven or eight pairs of abdominal prolegs, in contrast to five pairs on most caterpillars. The body is usually smooth, but with some species it is slimy or covered with spines, tubercles, or a waxy bloom. This group includes a number of important forest insects, some species feeding on conifers and some on hardwoods, but it is probable that only a few are represented in the Great Plains region.

Elm Sawfly
(Cimbex americana Leach)

The elm sawfly larva prefers elm and willow but has been recorded from linden, poplar, and maple. It is widely distributed over the United States east of Colorado, but is apparently most abundant in the Middle West.

The larva, which is approximately two inches long when mature, resembles the true naked caterpillars but can be distinguished from them by the presence of eight pairs of prolegs on the abdomen in addition to the three pairs of true legs, in contrast to five pairs of prolegs and three pairs of true legs on most caterpillars. The larva is pale yellowish white with a black stripe down the middle of the back and a row of black dots (conspicuous spiracles) along each side of the body. The body, which is commonly held in a coiled position, is very much wrinkled or ridged transversely.

The adults have four transparent wings and resemble some of the wasps or hornets. The body is steel blue to black with three or four yellow spots on each side of the abdomen. The antennae are knobbed at the end and are buff colored, except the bases, which are dusky.

The adult sawflies appear in May, and late in May or early in June lay their eggs singly in pockets made in the fleshy part of the leaf. These scars later appear as blisters. In approximately eight days the eggs hatch, and the larvae may be found feeding on the foliage up to the last of July or the first part of August. The full-grown larvae crawl into the debris on the ground or a short distance into the soil and spin their cocoons, where they remain over winter, to pupate in the spring.

In addition to the injury made in ovipositing in the leaves, the adults also have been recorded as girdling twigs, causing the portion above the girdle to die.

If the larvae are numerous enough to cause severe defoliation, the trees should be sprayed with lead arsenate, 1½ to 2 pounds to 50 gallons of water plus 6 to 8 ounces of linseed or fish oil. The spray should be applied when the larvae are small.

LEAF-FEEDING BEETLES

There are two families of beetles that may be important defoliators in the shelterbelts -- the leaf beetles and the blister beetles. Most of the leaf beetles feed on the leaves in both larval and adult stages. The flea beetles and the blister beetles are exceptions, for most species feed on foliage only in the adult stage. The leaf beetles are medium to small in size, oval, colored in various metallic hues, plain or patterned in dots and stripes. They are similar in appearance to the ladybird beetles, except that the latter are more rounded and hemispherical in shape. The leaf beetle larvae are rather stout, humpbacked, soft-bodied grubs with three pairs of true legs. They are dark in color and often spotted in blocks of black and yellow. The blister beetles are larger, and have the head distinctly set off from the wing covers by a narrow thorax. Once the blister beetles are recognized they will not be confused with the leaf beetles.

Leaf Beetles

Cottonwood Leaf Beetle
(Chrysomela scripta Fab.?)

The cottonwood leaf beetle is widely distributed over the United States. It attacks willows and poplars in both larval and adult stages. The beetles have been known to defoliate large areas of willow and poplar forests under favorable conditions.

The adult beetle ranges in length from 3/16 to 1/3 inch and has a ground color of yellow marked with elongate dark spots and lines. The head and thorax are black, with a red or yellow border on each side of the thorax. Beneath it is dark metallic green to black. In the coloration of the wing covers individuals vary from solid black to solid yellow.

The larva is dirty yellowish, with a dark brown head and black legs. Dorsally there are four rows of darker tubercles, the outer rows of which emit a milky fluid when the larva is disturbed.

The eggs are elongate-oval, yellow, soft, and are laid in clusters on the leaves of the host.

The beetles hibernate among debris and in protected spots. They begin feeding on the foliage as soon as it unfolds in the spring, and soon mate and lay their eggs. The eggs hatch in from five days to several weeks, according to the weather, and the young larvae skeletonize the leaves. When larger they consume the entire leaf except the larger veins. Upon maturing they fasten the hind end of their body to a leaf and transform to pupae in their partially cast larval skins. In the Dakotas there are probably three generations a year, while in the Southern States there may be five. There is an overlapping of the generations, so all stages of the insect may be found on the host at some time during the summer.

A lead arsenate spray, 2 pounds to 50 gallons of water and 8 ounces of fish or linseed oil applied early in the season when the larvae are small, is the only practical means of control. Two sprays at ten-day intervals may be necessary.

Spotted Willow Leaf Beetle
(Chrysomela interrupta Fab.?)

This species is similar in habits and appearance to the cottonwood leaf beetle. Frequently the two species may be found feeding on the same tree. The spotted willow leaf beetle differs from the background color of the cottonwood leaf beetle in that it is deep black beneath and instead of yellow, marked with rows of square or transverse black spots. The coloration varies from nearly black to nearly yellow. The larvae of the two species are not easily distinguished in the field.

The lead arsenate spray as recommended for the preceding species may be used for control.

Elm Leaf Beetle
(Galerucella xanthomelaena Schr.)

The elm leaf beetle was introduced from Europe and was first noticed in Baltimore, Maryland, in 1834. Since that time it has become widespread in the eastern part of the United States and on the Pacific coast. It has been recorded from Manhattan, Kansas, but no damage has yet been noticed in the shelterbelt zone. It feeds in both larval and adult stages on the foliage of American, English, Scotch, and Camperdown elms. The slippery, rock, and winged elms are usually not much injured.

The beetle is about one-quarter inch long. At the time of emergence it is light yellow with a blackish stripe on the outer edge of each wing cover, but with age it becomes dark olive green and the dark stripes become less distinct.

The mature larva is about one-half inch long, dull yellow in color, with two longitudinal black stripes down the back and a broad yellow stripe between them. On the yellow stripe are two longitudinal rows of tubercles bearing black hairs.

The adults hibernate in cracks and crevices or similar sheltered places. During the first warm days of spring they mate, and as soon as the foliage unfolds they fly to elm trees and eat round holes in the leaves. During May and June the females lay oval, or bottle-shaped, yellow eggs in clusters on the underside of the leaves. The eggs hatch in about a week, and the larvae feed in patches on the underside of the leaves, leaving the veins and upper epidermis. When a large portion of the leaf is eaten, it turns brown and falls. In two or three weeks the larvae become mature and drop or crawl down the trunk to the base of the tree where they transform to orange-yellow pupae. In six to ten days the pupae change to adults. The number of generations varies from one in the extreme Northern states to five in the extreme Southern States.

The application of lead arsenate, 2 to 2½ pounds to 50 gallons of water plus 8 to 10 ounces of fish oil, is the most effective artificial method of control. Care should be taken to cover the underside of the foliage, because the larvae feed on this side.

Flea Beetles

The flea beetles are a group of very small leaf beetles, usually of metallic color, that feed on the foliage of many species of plants. They may occasionally become pests by eating holes in the leaves of small trees in the newly planted shelterbelts. They are very active, have the hind legs fitted for leaping, and jump vigorously when disturbed. The adults of some species are rather general feeders, while others attack only one species or related species of host plants. The larvae of many species live on roots in the soil, but this stage is generally not injurious.

Flea beetles are difficult to control, because the arsenicals are apparently distasteful and repel them. However, fairly heavy doses of lead arsenate, 2 to 3 pounds to 50 gallons of water plus 8 to 12 ounces of fish oil or linseed oil, will give considerable protection if thoroughly applied to all the foliage. Several applications at about ten-day intervals may be required.

Blister Beetles

The blister beetles are of medium to large size, with the head distinctly set off from the wing covers by a narrow prothorax. The body and wing covers are comparatively soft. The color may be black, gray, tan, or some other shade, and plain, spotted, or striped. The most common species belong to two genera, Epicauta and Macrobasis. Only the adults feed on the foliage, infesting a variety of plants

including young trees. In the shelterbelts certain species prefer Caragana and locust foliage, although other trees may also be attacked. These beetles are distributed over the entire Great Plains region, but in 1935 damage was most prevalent in the northern Shelterbelt States, where the adults were present from the middle of June into August. The larvae of some species feed on grasshopper eggs, and in that respect are beneficial.

Spraying the foliage with 1½ pounds of lead arsenate to 50 gallons of water plus 6 ounces of fish or linseed oil will protect the young trees, largely by repelling the beetles, although some will be poisoned. As the new growth comes out beetles will return to feed on this unprotected portion, and it may be necessary to spray several times to give good protection. Sodium fluosilicate applied as a dust has given good control of certain species, but there is some danger of burning the foliage with this chemical.

GRASSHOPPERS

The grasshoppers may injure trees both by defoliation and by eating the green bark. The latter injury is the more serious as small trees may be girdled outright. Grasshoppers are discussed in detail under Bark Girdling Insects, page 39.

BORING INSECTS

ROUNDHEADED BORERS

The roundheaded borers are fleshy, often legless, grubs, white or yellowish in color, with the cylindrical elongate body tapering slightly from head to tail. They are the larvae of the long-horned beetles, belonging to the family Cerambycidae. With few exceptions only the larvae cause injury. The larvae can be found in a variety of situations, depending upon the habits of the species involved, from living trees to thoroughly decayed logs, and from dry to almost saturated tissue. The destructive species usually work in the cambium region for a time, later entering the wood.

Borers in the Bole and Larger Branches

Locust Borer
(Cyllene robiniae Forst.)

The locust borer is the most serious insect pest of black locust and is widely distributed throughout the United States wherever these trees are abundant.

The adult is a long-horned beetle about three-quarters inches long and is deep velvet-black in color, marked with narrow bands of bright yellow, of which the third on the wing covers is W-shaped.

Injury is caused by the legless, white, tapering, cylindrical larvae, which make large burrows in the sapwood and heartwood of the trunk and larger branches of the tree. This injury often results in the death of the tree. Even though the infested trees are not killed outright, they are often rendered unfit for useful products, greatly disfigured, or so badly weakened that a heavy wind will cause them to break off at point of heaviest attack. The presence of the borer is easily detected in early spring, when the leaves are unfolding, by characteristic brown or yellow pellets of excrement coming from "wet spots" (caused by the flow of sap) on the bark around the entrance to the larval galleries. Old attacks are recognized by calloused swellings of growth on the trunk, by dead limbs, or by large borer holes extending into the wood.

The beetles appear in large numbers during late summer or early fall, and may be found on the tree trunks or feeding on the pollen of goldenrod. The female deposits her eggs in rough crevices of the bark, usually from the first of September to the middle of October. The eggs hatch in about a week, and the young larvae bore into the inner bark, where they pass the winter in a dormant state. At about the time the buds begin to swell in the spring, the larvae resume their activity in the cambium area. Later they go into the woody portion, often penetrating to the pith. The larvae reach maturity during August, pupate at the end of the galleries, and emerge as adults during the latter part of August or in early September. The dates mentioned for the different stages apply to the central Shelterbelt States, and will be earlier farther south and later farther north.

There appears to be a close relationship between damage by the locust borer and tree vigor, the damage decreasing with an increase of vigor. Trees of the dominant crown class suffer less than those of the overtopped class. Therefore, effort should be made to maintain good tree vigor by proper cultural methods. Drought, fire, livestock grazing, or similar factors which tend to reduce the quality of the site may have an indirect effect upon locust borer injury.

The cutting of slow-growing young stands and severely injured stands offers promise of inducing sprout growth that is vigorous and resistant to borer damage. The cutting and burning of severely injured trees will tend to cut down the borer population, and it is also advisable to remove all severely injured or decadent trees in the general vicinity of shelterbelt strips to eliminate sources of infestation.

When planted with other species, locust is somewhat protected from the borer attack, and at the same time the vigor of the tree may be increased by the association, unless they are overtopped. The thin foliage of locust does not produce dense shade or abundant leaf

litter in pure stands and does not form a soil-protecting and building litter as it does in mixed stands.

The most effective, direct measure for locust borer control is the used of an orthodichlorobenzene emulsion applied as a spray on the infested trunks and larger branches. The stock emulsion is made as follows: 1 gallon of orthodichlorobenzene, 1 gallon of soft water, and 1 pound of liquid fish oil soap or common laundry soap. If the water is hard, 1 teaspoonful of washing soda should be added to each gallon. When laundry soap is used, the soap is dissolved in boiling water, and after cooling somewhat the orthodichlorobenzene is added and the ingredients thoroughly mixed. Pumping the mixture through a fine nozzle into another container with a bucket sprayer will aid in insuring a good emulsion. To make the spray solution, 1 part of this stock emulsion is mixed with six parts of water. The emulsion should be thoroughly stirred both before mixing with water and before applying to the trees, to prevent the chemical from separating out. The spray must be applied early in the spring when the locust leaves are unfolding, before the borers go into the wood. The trunk of the tree should be given a complete coverage, especially from the ground line to a height of five sr six feet. The spray should not be applied to the young branches or foliage, as there is danger of burning.

Tylonotus bimaculatus Hald.

The larvae of this long-horned beetle attack and often kill green ash in the Shelterbelt zone. They also occur in the eastern part of the United States and Canada, where they attack several species of ash and occasionally privet hedges. Apparently injury is most severe in the old green ash plantations on drier and poorer sites. Frequently this borer and the carpenter worm infest the same tree.

The beetles are three-eights to five-eights inch long, with the antennae of the males somewhat longer than the body and those of the female somewhat shorter. The adults are dark brown with two tan spots on each wing cover, one about one-third of the distance back on the wing cover and the other near the tip. Their legs are dark brown, nearly black, except for the swollen part of their femora or thighs, which are light tan.

The larvae are nearly cylindrical, slender, legless, white grubs, which may be nearly one and a quarter inches long when mature.

The beetles emerge through almost circular holes during the spring and summer, although the exact dates of emergence are not known, They were often found hiding under dead, loose green ash bark in Nebraska and South Dakota during the first part of July. Unemerged adults were found in the wood up to the last of July, and live adults under dead bark up to the first of September. By the last of August the first-year larvae were approximately one-quarter inch long and working under the bark next to areas of old attacks.

The first winter is spent as partially grown larvae one-quarter to one-half inch long in the cambium region. There were two definite larval sizes, with an occasional intermediate size, found over-wintering in their galleries, which indicates a two-year life cycle. Late in July of the second season the larvae bore into the sapwood and make extensive galleries. They pack the frass in their galleries behind them and leave no external evidence of their attack.

The borer attacks any part of the tree, but heaviest injury is at the base. Attacked trees are not killed outright, but die from the top downward over a period of years.

Injury in a plantation by this borer can probably be lessened by sanitation cuttings during the fall and winter. The stumps should be cut at least to the level of the ground and preferable an inch or two below the ground line, since the base of the tree is frequently heavily infested. The infested material should be burned before the beetles emerge in the spring. In areas where green ash is especially susceptible to attack by this borer and the carpenter worm, the ash trees should be planted only on the better sites.

Cottonwood Borer
(Plectrodera scalator Fab.)

The cottonwood borer is particularly injurious to cottonwood, and occasionally to willows, in Oklahoma, Kansas, and Nebraska. The principal injury is caused by the larvae boring under the bark and in the wood at and just below the ground line. This borer often girdles the tree or so weakens it that it breaks off in the wind. The adults in the act of egg laying also cause some injury to very young trees.

The adults are large, black and white mottled, long-horned beetles, the female measuring from one and a quarter to one and a half inches, and the male slightly less. The background color is black, which is mixed with patches and stripes of white or cream. Near the middle of each side of the prothorax is a black spine. The antennae of the females are about as long as the body, while those of the male are longer. The larva is nearly two inches long when mature, legless, cylindrical, distinctly segmented, and white or yellowish in color.

The adults emerge during late June, July, and August. The eggs are laid during July and August in rather deep pits chewed in the bark of the base of the tree at or just below the ground line. Two or three such scars made on a small seedling may be sufficient to girdle the stem or seriously weaken it. The smaller and younger trees are preferred for oviposition, although trees of all sizes are attacked. The eggs hatch in about two weeks, and the larvae work under the bark and into the wood. On the younger trees the borer activity causes abnormal swelling on the butt. The larvae pupate in their galleries during June and July of the second year after hatching, and the adults emerge during late June, July, and early August. Thus the insect completes its cycle in two years.

Barriers made of such material as burlap, wire screen, or tar paper, placed around the bases of the young cottonwood trees, may protect them from oviposition and injury. Such barriers will probably be needed for several years, or until the trees become large enough to resist or withstand attack. The borers can be cut out with a pocket knife, if this is done by early September of the first season. After this time the borers may be in the wood too deep to be reached. Paradichlorobenzene crystals and naphthalene crystals have been suggested for killing the borers, but these chemicals should be tested experimentally before being used on a large scale, as there is danger of killing the trees.

Poplar Borer
(Saperda calcarata Say)

The poplar borer is a pest of all species of poplars, and occasionally of willows, throughout the United States and Canada wherever its hosts are found. The boles and larger branches of infested trees have blackened, swollen scars, from which extend the large, wandering larval galleries under the bark and into the wood.

The beetle is one of the long-horned beetles, about an inch long, and somewhat cylindrical. The background color is gray, marked with faint, yellow, irregular spots and peppered with tiny black spots. The thorax bears three yellow stripes on the dorsal side.

The larva is a cylindrical, tapering, legless, cream-colored grub, about an inch long when mature. The pronotum (upper side of the first body segment) bears very small spines.

The eggs are laid during June, July, and August in irregular holes gnawed through the bark into the cambium. During the first season the larvae work in the cambium region, and a small tree may be encircled and killed. A knotty swelling frequently appears at the point of feeding. During the remainder of the cycle the larvae make extensive galleries in the sapwood and heartwood. The larva pupates at the end of its gallery, and the adult emerges through the hole made by the larva for pushing out the grass or borings. This frass may accumulate to a depth of several inches at the base of heavily infested trees. Thees are often so badly honeycombed by galleries that they readily break off. The normal developmental period is two years, but at high elevations, ranging from 6,000 to 9,000 feet in Colorado, and in Canada the period is extended to three years.

There is a tendency for the poplar borer to concentrate its attacks upon trees already infested or weakened. Injury to surrounding trees may be greatly reduced by cutting and burning these favored trees, commonly called "brood" trees, or by splitting the infested logs and exposing them to the direct rays of the sun. Fast-growing trees are less attractive to the beetles than slow-growing ones. Coal tar creosote painted over the egg scars soon after oviposition is advised for killing the eggs.

Elm Borer
(Saperda tridentata Oliv.)

The larvae of the elm borer feed between the bark and the wood of elm. They prefer recently cut or dying elm but under certain conditions, will also attack apparently normal trees. The insect probably occurs throughout the range of American elm.

The beetle is from three-eights to one-half inch long, gray in color, with a submarginal orange-red stripe on each wing cover, from which branch three cross bars of the same color. The bar nearest the base is nearly transverse and the other two are oblique. Each bar except the middle one has a small black spot just back of it. The thorax has a lateral orange-red band on each side, just below each of which are twin black spots. The larva is white, legless, about an inch long, and similar in appearance to other roundheaded borers.

The larvae overwinter in their galleries beneath the bark or a short distance in the wood and pupate in the spring, probably during May. The adults emerge during late May, June, and July. The females lay their eggs on the bark, and the larvae bore into the bark immediately after hatching. The presence of brown frass lodged in the crevices indicates the activity of the larvae. The numerous winding galleries loosen the bark so that it can be easily peeled off. The larvae apparently reach full size in one year.

Badly infested trees should be cut and burned before the beetles emerge in the spring. Green slash should not be allowed to remain on the ground in or near elm plantations, as the borers may breed up in such material and attack the living trees. Maintenance of good tree vigor will aid in preventing injury by this borer.

Saperda concolor Lec.

The larva of this long-horned beetle produces a gall from one and a half to two inches in diameter on the young stems of poplars and willows. The insect ranges throughout the eastern and central parts of the United States and Canada.

The beetle is about one-half inch in length, black with numerous small punctures, and covered with a dense gray or yellowish-gray pubescence. The antennae are ringed alternately with black and gray. The larva, which is similar to other roundheaded borers, mines under the bark and in the wood. When nearly ready to pupate, it makes a short, straight, vertical gallery in the wood. The following May and June the adult emerges. The female gnaws a longitudinal incision in the bark about three-quarters inch long and deposits an egg in each end. The insect is reported as completing its life cycle in one year.

Young trees on which the galls are found should be cut and burned. Injury is most severe in slow-growing stands, and anything that can be done to stimulate growing will reduce the damage by this borer. Only the young trees are injured.

Pole Borer
(*Parandra brunnea* Fab.)

This borer attacks posts, poles, and structural timbers in contact with the ground, and also the heartwood of many species of living trees. The borer gains entrance to the heartwood through scars and wounds, and its work hastens decay. Frequently shade trees are so badly hollowed out that they break off. The insect is distributed in the United States east of the Rocky Mountains.

The adults are chestnut brown, glossy, and about three-quarters inch long. The larvae are cylindrical, cream-colored, roundheaded borers.

The adults emerge during late July and August. The females lay eggs in old scars or in cracks in the wood. The larvae bore into the inner sapwood and heartwood and completely honeycomb the inner portion until there is nothing left but a shell of sapwood. In some cases the adults do not emerge but mate and lay eggs in the same cavity in which they developed. The wound through which they gained entrance may heal over and show no sign of the attack.

All decadent and badly infested trees should be removed. All wounds should be painted to prevent oviposition by the beetles.

Leiopus variegatus Hald.

This insect is one of the roundheaded borers that works in many species of trees found in the shelterbelt region. Little is known about its habits, but apparently it causes little damage. It is mentioned here because of its abundance in some of the decadent wood lots.

The adult is one of the smaller long-horned beetles, mottled brown and black, and about 3/8 inch long. Its aetennae are ringed alternately with light and dark bands. The adults are found resting under loosened bark during June and July. If this insect appears to be injuring the trees, the heavily infested branches or trees should be cut and destroyed.

Twig Girdlers and Pruners

Oak Twig Pruner
(*Hypermallus villosus* Fab.)

The oak twig pruner is a pest of oak, hickory, pecan, maple, locust, hackberry, elm, walnut, and many other species of trees. It

is a common enemy but not a major one.

The larva, which is cylindrical, cream-colored grub, burrows down the center of a twig and when nearly mature girdles the branch from within, leaving only a thin shell of bark so that the branch later breaks off in the wind and falls to the ground. In the center of the twig there is a hole plugged with shreds of wood, back of which is the larva.

The adult is a slender, brown, long-horned beetle, mottled with patches of short gray hairs. It is about five-eights inch in length. The tip of each wing cover is notched.

The beetles appear during the spring or early summer, and the females lay their eggs in the twigs. The larvae feed beneath the bark for a while and then bore into the stem. Late in the summer the twigs are severed and fall to the ground. The insects overwinter in these twigs on the ground in the larval or pupal stage. There is one generation a year.

For control, the severed branches containing the larvae should be collected in the fall and burned. To be effective, all the infested branches in a general area must be destroyed.

Twig Girdler
(Oncideres cingulatus Say)

The adults of this insect have the peculiar habit of girdling the twigs in which the eggs are deposited. These branches break off in the wind, fall to the ground, and the larvae feed in the severed stems. The injury does not kill the host but often deforms it. The insect has been recorded on hickory, elm, poplar, honey locust, and oak. It occurs throughout the eastern part of the United States and as far west as the Shelterbelt States.

The beetles are slightly over one-half inch long, grayish brown with a light gray area on the middle third of each wing cover. The larva is one of the roundheaded borers and ranges in length from one-half to three-quarters inch.

The adults are in flight from the last of July to September, at which time the females lay their eggs and cut the twigs. The eggs hatch and the young larvae pass the winter in the twigs on the ground. Development is completed the following spring, and pupation occurs during July. The adults emerge in about two weeks. There is a single generation each year.

The insect can be controlled by collecting and burning the severed branches in the fall.

FLATHEADED BORERS

The flatheaded borers are so named because of the much widened and flattened first few body segments, which appear as a "head." They are whitish, legless grubs, with the body elongate and distinctly flattened. The adults of this family are known as metallic wood borers or buprestids, and many are colored in brilliant iridescent shades. Insects of this group usually attack trees weakened by other agencies.

Flatheaded Apple Tree Borer
(Chrysobothris femorata Oliv.)

This insect attacks many species of forest and fruit trees after they are one or two years old. Some of the common forest-tree hosts are poplars, willow, oak, elm, hackberry, maple, boxelder, and walnut. This borer is widely distributed over the United States and is one of the worst shelterbelt pests.

The beetles are about one-half inch long, rather broad and flat, with a dark coppery-brown metallic hue above, and each wing cover bears two punctured, brassy-green areas near the middle. The underpart of the body is bronze, and the back beneath the wings is a brilliant metallic greenish blue.

The larva is a cream-colored, legless grub, about one inch long when full grown. The first three body segments are much swollen and flattened, which accounts for the name "flathead." Just back of the true head on the dorsal side of the first large flattened segment, is a round brown plate with a figure V. The larva is usually found curved in the shape of a U in its gallery.

The beetles emerge in the spring soon after the apple trees bloom and are in flight for several weeks. They are very active and take flight quickly when disturbed. They are sun-loving insects and on hot, clear days may be found on the sunny side of the trees. The female lays her eggs in cracks or around scars in the bark. These are pale yellow, flattened, disclike, wrinkled, and about 1/20 inch in diameter. The eggs hatch in fifteen to twenty days, and the larvae enter the bark directly beneath the egg. If the tree is vigorous, the borer is unable to survive within the growing tissue and soon dies; or it may live in the outer bark for months and finally die, unless the tree becomes weakened sufficiently to enable the borer to penetrate the inner bark undisturbed by the flow of sap. Late in the summer the maturing larvae bore into the wood to a depth ranging from a fraction of an inch to several inches, and at the end of the gallery construct a flattened pupal cell in which they pass the winter. Under favorable conditions the life cycle is completed in one year, but sometimes the period may be two years or possibly longer. There is little external evidence of the presence of the borer larvae, although occasionally the injured spots may be darker or the bark slightly depressed or cracked.

Since normal and vigorous trees are rarely injured by this borer, it is important to keep the trees healthy by good cultural methods. Frequently the young trees are injured during the first few years after being planted. The use of such protectors as thin veneer, paper matrix, burlap, or wire screen, placed around the base of the trees up to the first large branches, will prevent oviposition on the lower bole. It has been reported that a board placed so as to shade the lower trunk will discourage attack. It appears that little dependence can be placed on repellents, poisoned washes, or chemicals to kill the eggs and larvae.

The younger borers can be cut out during the summer, before they have done serious damage. The elimination of possible breeding places, such as old decadent and seriously weakened trees, in the vicinity of shelterbelt strips will reduce the danger of injury. It has been suggested that poles, covered with some sticky material set up in a plantation will trap many of the beetles when they alight; also that fresh slash of favored host trees scattered around the outskirts of plantations will provide attractive places for egg laying, and this material can be burned at the end of the summer.

Honey Locust Borer
(Agrilus difficilis Gory)

This borer was found attacking honey locust at Woodward, Oklahoma and near McCook, Nebraska, in 1935, and is no doubt distributed over much of the shelterbelt region.

The adult is an elongate beetle, five-sixteenths to one-half inch in length. The head is green in front, becoming purplish or blackish green at the top, the wing covers are blackish green with a distinct purplish reflection in certain lights, and the body beneath is copper-colored and shining.

The larvae are one to one and a half inches long, one-eighth inch in width at the widest point, flattened, cream-colored, legless, and distinctly segmented. The second and third segments back of the head are about half as wide as the widest segments, and the last segment terminates with a pair of short, pointed, hard, brownish-black projections.

The adults are commonly seen during July and August running over the surface of the bark. The female lays her eggs at the roughened bases of small twigs or at rough spots on the limbs or trunks. A thick gum exudes at the point of attack. The larvae mine in the cambium beneath the bark, packing the gallery back of them with their borings. They make long winding galleries and when mature bore a short distance (usually one-quarter to one-half inch) into the sapwood and construct a cell in which they pupate. The adults make a D-shaped hole in emerging.

Old, decadent trees and those weakened by drought are most subject to attack. Heavily infested trees should be cut and burned before late spring, to prevent emergence of the beetles and their attack on other trees. The infested trees at Woodward, Oklahoma, which were suffering from drought, overcame the attacks after irrigation, which apparently drown out the young larvae.

BARK BEETLES AND WEEVILS

The bark beetles, or scolytids, comprise a large family of small, darkbrown, cylindrical beetles, which work under the bark of trees. Most of the species attack only dying or dead trees, but many are capable of killing apparently healthy ones. The larvae are stout, legless, whitish grubs, with brown heads.

The weevils, or snout beetles, are oblong-oval and have a peculiar lengthening of the portion of the head bearing the mouth parts to form a beak. The larvae resemble those of the scolytids.

The adult bark beetles usually construct galleries in the inner bark, along which they lay their eggs. The adult weevils discussed in this paper deposit their eggs in holes or scars gnawed in the bark.

BARK BEETLES

Cedar Bark Beetle
(Phloeosinus dentatus Say)

The cedar bark beetle attacks juniper in the southern section of the country and arborvitae in the northern section. The beetle prefers recently cut trees but will also attack suppressed and weakened trees, and under certain conditions may become a serious pest. The adults feed by making pits or short galleries in the twigs, thereby killing many of them. Adults are in flight apparently throughout most of the summer.

The adults are small, dark brown or black, stout cylindrical beetles, about one-tenth of an inch long. The larvae are small, curved, white, legless grubs. The adults make galleries from one to two inches long in the cambium region, running parallel with the grain of the wood. The female lays her eggs in regularly and closely placed niches along the sides of the gallery. The larval mines are also in the cambium region and extend out from the egg gallery. Near the junction of the entrance hole and the egg gallery is an enlarged chamber known as the nuptial chamber. The egg gallery usually extends upward from this chamber, but occasionally it may extend downward.

This insect can be controlled by felling and burning all infested trees before the beetles emerge. Felling and peeling the infested parts may also be utilized, but peeling is effective only while the insect is in the larval stage. Peeling the usable portion of the bole at this time, and burning the remainder of the tree, would also be satisfactory.

Ash Bark Beetle
(Leperisinus aculeatus Say)

The distribution of the ash bark beetle is nearly identical with that of its host trees, the various species of ash. It attacks weakened, dying, or dead trees and branches, but is not a serious pest of normal living trees. The beetle is mentioned here because it is so common in old decadent green ash tree claims in the Plains States.

The beetles measure about1/10 inch in length, and are dark brown with color markings formed by light-colored scales. The adults emerge in the fall and fly to other trees, where they make short hibernation and feeding burrows in the bark. When made in living trees these burrows cause black spots in the phloem. In the spring the overwintered beetles make transverse egg galleries, with two branches extending about an inch in opposite directions from the entrance tunnel. Near the junction is a small niche, with serves as a turning niche and nuptial chamber. The larval galleries are longitudinal, straight, short, regularly spaced and nearly equal in length. The larvae pupate in small cells at the end of their galleries. The adult emerges through a round hole which it makes to the surface and obtains food from a fresh host before making an attack for egg laying. There appear to be several generations a year, at least in the Southern States.

If this bark beetle appears to be injuring living ash, it can be controlled by peeling the infested trees while the insects are in the larval stage. Felling and burning all infested trees before the adults emerge is a more effective method of control.

Bark Weevils

Black Elm Weevil (Magdalis barbita Say)

Red Elm Weevil (M. armicollis Say)

The larvae of these two weevils work in the inner bark of the boles and branches of weakened elm trees. They are distributed from the eastern part of the United States and Canada as far west as Colorado. The two species are similar in habits and appearance. The adults of the black elm weevil are black, while those of the red elm weevil are reddish and more slender. In the larval stage they are practically indistinguishable. The weevils are about one-quarter inch long and have a long slender beak. The larvae are curved, white, legless grubs.

In the vicinity of Colorado the winter is passed in the mature or nearly mature larval stage in the larval mines. They pupate at the end of these galleries in the spring, and the adults emerge through small, round holes in late May or June. In laying their eggs in the bark, preferably under smooth scar tissue or under smooth places on the bark, the adults make small pits. The young larvae make winding galleries leading from these points of oviposition. Apparently there is one generation a year.

To prevent attack, elm trees should be maintained in as healthy a condition as possible. The infested trees or parts of trees should be cut and destroyed to reduce the insect population. The adults feed slightly upon the foliage during late May and early June. It is possible that the beetles could be poisoned at this time by spraying the foliage with lead arsenate.

BORING CATERPILLARS

Wood-Boring Caterpillars

Carpenter Worm
(*Prionoxystus robiniae* Peck)

The carpenter worm is widely distributed in the United States and has been recorded from a great many hosts. In the Great Plains region green ash is apparently the preferred host. Damage by this insect and the roundheaded borer *Tylonotus bimaculatus* makes the growing of green ash on the porrer sites difficult.

The adult female moths have a wing spread of two and a half to three inches, the front wings being mottled gray, the smaller hind wings plain brown. The male moth is similar but smaller, and has an orange-red spot on each hind wing. The larvae are rather fleshy, naked caterpillars with well developed true legs and five pairs of abdominal prolegs. The younger caterpillars are whitish tinted with red, but those that are mature are pale greenish white. The head and dorsal shield (just back of the head) and the small tubercles on the body segments, from each of which arises a hair, are dark brown. The mature larvae are two to three inches in length.

The moths emerge during June, and by early July most of them have disappeared. The females lay their olive-green, oval eggs in masses or singly in cracks and crevices of the bark soon after mating. One female is capable of laying from 200 to 300 eggs. The eggs hatch in eleven to fourteen days, and the young larvae feed for a short time on the empty eggshells, but within a few hours they start boring into the bark or enter openings made by the older larvae. They feed in the sapwood just beneath the bark for a year or two, and not until the third or fourth year do they make large galleries into the heartwood. The frass or borings are pushed out of an opening through the bark. This material is loosely webbed together with silken threads and when fresh is conspicuous in the bark crevices and at the entrance to the burrows.

Frequently this sawdustlike material piles up at the base of a tree to a depth of a couple of inches. In North Dakota the larvae reach maturity and pupate during May of the fourth season. In Nebraska and farther south the insect may be able to complete its life cycle in three years. The pupal period lasts from fourteen to nineteen days. When the moth is ready to emerge, the pupa works its way through the opening of its burrow until about one-third of its body protrudes. The skin splits open and the moth emerges. These empty pupal skins protruding from the old galleries are rather conspicuous and may remain there for months.

The female moths are poor fliers, and their spread to new areas is not likely to be rapid unless the insect is distributed in fresh wood products. Moths have been known to emerge a year after infested trees were felled and cut into firewood, fence posts, or poles. Consequently, infested material should not be utilized or placed in the vicinity of plantations until the second year following cutting.

The larvae can be killed by squirting a few drops of carbon disulphide into the active galleries and closing the opening with mud or grafting wax. This type of control is applicable to this insect because it maintains an open burrow. All badly infested trees should be cut and burned by early spring to decrease the insect population.

Ash Borer
(Podosesia fraxini Lugger)

The ash borer is injurious to young ash in the Dakotas, Nebraska, and other northern Prairie States. The larvae bore into the young trees, usually near the base, and may either kill the trees or weaken them so that they break off in a strong wind.

The adult is one of the clear-winged moths, the female having a spread of a little over an inch. The fore wings are narrow and opaque, except for a short transparent and orange-brown basal streak. The hind wings are transparent with yellowish-brown margins and veins, and are yellowish beneath. The abdomen is black with a transverse band of yellow on the posterior edge of each segment, or the last four segments may be entirely yellow. The larvae are white, naked caterpillars. Little is known about the life history of this insect.

Badly infested trees should be cut and burned to prevent the insects from emerging and attacking other trees.

Pitch Moth
(Dioryctria ponderosae Dyar)

This species has been found on native ponderosa pine in Nebraska, South Dakota, and California. The larvae make irregular burrows in the cambium region, and repeated attacks at the same point frequently result in the girdling of saplings or the formation of scars which weaken the

bole of larger trees. Trees less than two inches in diameter are seldom attacked. In the plantations at Halsey, Nebraska, the moth infests Scotch, Austrian, ponderosa, red, and jack pine. By far the worst damage has occurred in the Scotch and Austrian pine plantations.

The full grown larvae are from three-quarters to one inch long. They are usually light brown with a darker head, and have a series of conspicuous, small black dots or tubercles on the body. The moths are blackish gray, and have across the forewings two narrow W-shaped bands of gray bordered with black. The wing spread is about one and a quarter inches.

In Nebraska the adults emerge from late July to early September, and deposit their eggs singly under the bark scales on the bole. The eggs hatch the same season, but the young larvae hibernate in small cocoons spun under the scales of bark, apparently without feeding. Early the following spring they bore through the bark and begin their burrowing. As the work progresses the exuding pitch forms in a large, irregular mass on the bark. The larvae transform to pupae in July, pupation taking place in the burrows, or occasionally in the mass of pitch. The moths emerge about three weeks later, thus completing a full generation in one year. The empty pupal skins remain in the pupal cell, instead of protruding from the exit hole as in the case of the clear-winged pitch moths, some species of which also attack pine.

Infested trees are often reattacked year after year, and it is on these trees that most of the moths are produced. The cutting of these heavily infested "brood" trees, which are frequently deformed or broken, will reduce an infestation. This cutting should be done during the winter, If the trees are not over seven or eight inches in diameter, they will dry out sufficiently by early summer, if left in the open, to prevent the maturing of the small overwintering larvae. In the lightly infested trees the larvae may be cut out with a knife at the time the pitch masses appear on the bark late in the spring.

Shoot and Bud Caterpillars

Midwestern Pine Tip Moth
(Rhyacionia frustrana bushnelli Busck)

The midwestern pine tip moth attacks practically all the two- and three-needle pines, the larvae feeding in the buds and new growth shoots. It occurs in Nebraska, the Dakotas, and Minnesota, and has been found in many of the isolated windbreak plantings in central Nebraska.

The larvae are yellowish with a brown head, smooth, and nearly one-half inch long when full grown. The moths are light reddish brown, the forewings somewhat mottled by darker patches. The wing expanse is a little more than one-half inch.

Two generations occur in Nebraska. The winter is passed as pupae in cocoons in the litter and soil. The moths emerge during April and early May and deposit their eggs singly on the needles and shoots. These eggs hatch in two or three weeks, and the young larvae bore into the new shoots near the apex. When mature, in June, the larvae transform to pupae in the infested tips. The moths emerge for the second flight in late June and the first half of July. The eggs of this generation hatch in from six to ten days, and in late August the larvae drop to the ground to spin up for the winter. In the Black Hills and in North Dakota only one generation is produced each year, the moths probably being in flight in late May and early June, and the larvae leaving the tips two months later. One or two larvae will hollow out only the buds or apex of the new shoot, but where they are numerous the entire shoot may be riddled with their burrows. Although trees are seldom killed, they are stunted and deformed by repeated heavy infestations, and with the less vigorous trees height growth may be prevented for a number of years. The tree seedlings and saplings size are subject to injury, but after a height of twenty to twenty-five feet is attained the damage decreases.

There is evidence that this pest is frequently introduced into isolated plantings on nursery stock, in the egg stage. All spring-dug stock in nurseries where tip moths occur, or in nurseries adjacent to infested native pine, should dipped in a two percent white-oil emulsion before shipping, to destroy the eggs. Once established, the insect is controlled with difficulty. Infestations may be reduced temporarily by destroying the infested tips while the larvae are still present, or by spraying the trees with a two percent white-oil emulsion during the egg-laying period. In Nebraska two applications at ten-day intervals in mid-May or three applications at six-day intervals during the summer flight period in early July gave a good reduction in the current injury. To be most effective the summer applications should be timed with the appearance of the first moths, the first spray being applied six days later. A parasite, Campoplex frustranae Cush., introduced into plantations at Halsey Nebraska, from Virginia, gave good control for a time. It is probable that this parasite could be used in shelterbelt plantings with some success, especially in those parts of the region where two generations of the tip moth develop.

Southwestern Pine Tip Moth
(Rhyacionia neomexicana Dyar)

This moth is somewhat larger than the midwestern species, but causes the same type of injury and apparently will attack any of the two- and three-needle pines. It is known to occur in the Black Hills, in Nebraska, and throughout the Southwest.

The full grown larvae are nearly three-quarters inch long, and can usually be distinguished from those of the midwestern pine tip moth by a more reddish color and a dark spot on the back at the anal end. The moths have a wind spread of from three-quarters to one inch. The basal two-thirds of the forewings is dark gray, the outer third a light yellowish brown.

A single generation occurs annually throughout its range, the first moths appearing in the spring about the time tree growth begins. In Nebraska the moths are in flight during April and the first half of May. They deposit their eggs in groups on the inner surface of the needles, just above the bundle sheath. The early eggs do not hatch for three or four weeks, but the late eggs may hatch within ten days during warm spring weather. In general, hatching starts about the middle of May. Infested shoots usually contain a number of larvae, as a result of the eggs being placed in groups. When full grown the larvae crawl down the bole of the tree and spin cocoons in the bark crevices at the ground line, where they transform to pupae and remain until the following spring. In Nebraska the tips are abandoned during July.

Control measures are similar to those suggested for the other tip moth. In addition it may be possible to destroy the pupae of this species, which are concentrated at the base of the trees in late summer instead of being scattered in the litter and soil.

HORNTAILS

Pigeon Tremex
(Tremex columba L.)

The pigeon tremex is not a notably injurious insect, as it attacks only dead trees or dead parts of living trees. It may hasten their death, however, by carrying its burrows into living sapwood, thus spreading fungi, or by weakening the tree so that it breaks off. The larva bores in the sapwood and heartwood of such species as maple, elm, and hickory. It is occasionally injurious to trees partly killed by other borers.

The adult is a wasplike insect one and a half inches or more in length and is related to the wasps and sawflies. Its body is dark brown, and the cylindrical abdomen is marked with circular bands of yellow. The abdomen of the female ends in a hornlike projection, which she uses to bore a hole through the bark and into the wood where she lays her eggs.

The larva is cylindrical, white, with three pairs of short, poorly developed legs and a short spurlike structure extending from the posterior end.

Little is known about the life history of this insect, The adults probably lay their eggs during July and August. The length of its life cycle has not been discovered.

Trees kept in a healthy condition and uninjured will not be infested by this insect. The presence of this borer in a tree indicates that it is in a decadent condition and unless it is a valuable tree it might be removed and the wounded place painted with a good paint.

ROOT-FEEDING INSECTS

MAY BEETLES OR WHITE GRUBS

The May beetles, or June bugs (Phyllophaga spp.), are the adults of the common white grubs. The adults feed on the leaves of oak, ash, hickory, poplar, elm, willow, locust, hackberry, and other trees, and when abundant may completely defoliate a wood lot. The larvae, or white grubs, the stage that causes the most damage, feed on the roots of various plants and are sometimes serious pests in forest nurseries and forest plantings. There are many species of May beetles, and they are very common over the entire United States.

The beetles are light to dark brown in color, and range in length from one-half to seven-eights of an inch. The larvae are white, fleshy grubs with brown heads and three pairs of prominent legs. When at rest they curl up in the shape of a U.

The majority of white grubs have a three-year life cycle in the central and more northern Shelterbelt States, but in North Dakota the cycle may be lengthened to four years and in the South shortened to one or two years. A typical three-year cycle is as follows: The beetles lay their eggs in the soil during April, May, or June. The larvae that hatch from these eggs are small and cause little damage the first summer. They resume feeding in May of the second season and they feed until the arrival of cold weather in the fall. They do the most damage during this season. The grubs continue to feed during the early part of the third season and in July pupate in an earthen cell. Although the pupae change to adults the latter part of this season, the beetles do not emerge from the soil until the following spring.

If the adults are very numerous, the shelterbelt trees can be protected from defoliation by thoroughly spraying them with lead arsenate, 2 to 2½ pounds to 50 gallons of water. It is very difficult to control the white grubs in the soil. Young trees should not be planted on sites that have been in sod and heavily infested with the grubs. Land under cultivation is not likely to be heavily infested.

TERMITES OR "WHITE ANTS"

The termites, or so-called "white ants," are either wood-dwelling or ground-dwelling. They feed on cellulose, usually dead wood or wood products, but occasionally some subterranean forms feed on living trees, shrubs, and other plants. The barren-lands subterranean termite (Reticulitermes tibialis Banks) has been found doing considerable damage to seedlings and planted trees in Oklahoma and Texas. This species occurs principally west of the Mississippi River to the west coast and as far north as the latitude of northeastern Nebraska. The colony is located entirely in passages in the soil,

and the termites feed by tunneling in the roots of the young trees, soon causing their death. They continue to feed until the roots and part of the stems are entirely hollowed out and then move on to other trees. When a tree is small, one or two termites may cause its death in a few days. Thus it can be seen how destructive a single small colony may become in a nursery of one-year seedlings. Where colonies are numerous within a nursery the problem becomes acute.

Termites as they are found in the underground passages are usually delicate, white, soft-bodied insects, resembling ants except that the "waist" is not constricted and they are white or cream-colored. They usually occur in large numbers, which vary with the age of the colony. They avoid the sunlight, and in wood or plants always construct their tunnels and feed in the dark, never coming out into the light.

At certain seasons of the year black, winged individuals appear in colonies. These winged forms usually wait until after the first heavy rains in the fall before swarming and establishing new colonies. In the southern region another swarming occurs in the spring. These insects usually pair off, mate, and endeavor to establish primary colonies. The female lays eggs which hatch in thirty to ninety days. The communal life is rather complicated, different castes such as workers, soldiers, and reproductive adults being represented in each colony.

Control of termites in nurseries is yet in the experimental stage. However, preliminary tests with soil fumigation indicate that these insects can be successfully controlled without injury to well developed seedlings. Paradichlorobenzene crystals worked into the top three or four inches of soil at the rate of 3½ pounds per 100 square feet of soil surface, the crystals being kept at least two inches from the trees, gave good control and did not injure green ash seedlings treated in September at Oklahoma City, Oklahoma. A fifty percent carbon disulphide emulsion, three pints to 50 gallons of water, gave good control applied at the rate of two quarts per square foot of soil surface, also with no noticeable injury to the trees when applied in September. These chemicals have not been tested for injury to young seedlings early in the summer.

BARK-GIRDLING INSECTS

CUTWORMS AND ARMYWORMS

Cutworms and armyworms are the larvae of the night-flying noctuid moths, or millers. Although primarily pests of field crops and herbaceous plants, they have caused considerable damage to young trees in the shelterbelt strips by girdling the stems and branches before the foliage comes out in the spring, and later in the season by defoliation. They may be divided into four kinds according to their

feeding habits: (1) Climbing cutworms, which climb trees, vines, and shrubs, usually in the spring, to feed on the buds, young green bark, and foliage; (2) armyworms, which frequently occur in large numbers and devour the vegetation as they travel together over the ground; (3) garden or solitary cutworms, which cut off the plants at the surface of the ground; and (4) subterranean cutworms, which feed on the plant under the soil surface. The various species of armyworms and cutworms often cause more than one of the above mentioned types of damage. Feeding in most cases takes place at night, and during the day the larvae hide in the soil, or under clods, clumps of grass, dried cow chips, and other objects.

Some of the species overwinter as partially grown larvae and begin feeding during the first warm days of March and April. Others overwinter as pupae and occasionally as adult moths, and damage by these species occurs during late spring and summer when the young trees are in foliage.

Cutworms and armyworms can be controlled, except in the last larval stage, by scattering poisoned bran mash. The bait should be made up as follows:

	Large Quantities	Small Quantities
Coarse wheat bran.....	100 pounds	5 pounds (1 pk.)
Crude arsenic or paris green....	5 pounds	4 ounces
Molasses or sirup.....	2½ gallons	1 pint
Water.....	10 to 12 gals.	2 to 3 quarts

The poison, molasses, and most of the water should be combined and then thoroughly mixed with the bran. The solution should be stirred constantly while it is being applied to the bran to prevent the arsenic from settling out. Enough water should then be added to make a crumbly mixture that will just stick together when tightly squeezed in the hand.

The bait should be thinly scattered over the area at the rate of 10 to 20 pounds (dry weight) per acre before the caterpillars are full grown. In the last larval stage the larvae chew on the bait and foliage, but apparently they do not swallow it. Control measures applied when they are full grown would therefore be ineffective. Since the cutworms feed at night or late in the afternoon, and the bait is not attractive after it has dried out, on warm days it is necessary to spread the mash at this time.

In dealing with the army cutworm (Chorizogrotis auxiliaris Grote), which is probably the most injurious cutworm in the shelterbelts, it is not advisable to cultivate the strips, except those that are several years old, until the larvae are mature. In Kansas this usually occurs by April 15, in Nebraska by April 30, and in the Dakotas by May 15. These cutworms prefer the volunteer wheat and weeds, but when deprived of this food they will feed on the bark and buds of the young trees.

If necessary to apply the poisoned bait, a small quantity, the size of a hulled black walnut, scattered around each tree at the proper time will give protection. If there is danger of the cutworms migrating into the strips from adjoining fields, it may be advisable to scatter the mash in a band approximately a rod wide around the strips. The general abundance of this species can be determined by searching around clumps of volunteer wheat or weeds in the strips or under dried cow chips in the pastures. In the spring of years when cutworms are abundant it is not uncommon to find from three or four up to a dozen worms around one clump of wheat or under one cow chip. The larvae curl up when disturbed, and this species can be distinguished from other cutworms by the presence of a fine white line down the middle of the back. The moths emerge during May or early June and disappear during the summer. They reappear in September and lay their eggs. The eggs hatch and the partially grown larvae pass the winter. There is one generation a year.

A few of the other cutworms and armyworms that are likely to be common in the shelterbelts are as follows: The dingy cutworms (Feltia subgothica Haworth and F. ducens Walker); the variegated cutworms (Lycophotia margaritosa saucia Hubner);the samdhill cutworm (Euxoa detersa Walker) in the sandhills of Nebraska; and the yellow-striped armyworm or cotton-boll cutworm (Prodenia ornithogalli Guen.) south of Nebraska.

GRASSHOPPERS

Grasshoppers are primarily pests of agricultural crops, but during outbreaks they may defoliate and chew on the green bark of all species of shelterbelt and fruit trees. There are many species of grasshoppers, but the most important ones in the Middle Western States are the differential, the two-striped, the lesser migratory, the red-legged, the Carolina, and the clear-winged grasshoppers.

The differential grasshopper (Melanoplus differentialis Thos.) is one and a half inches long, brownish or yellowish green, more yellow below than above, with clear, glossy hind wings and its hind legs are usually distinctly marked with yellow and black chevron-shaped bars on the sides of the thighs.

The two-striped grasshopper (Melanoplus bivittatus Say) is yellowish-green, slightly more robust and shorter than the preceding species, and bears two yellow stripes down its otherwise brown back from its head to the end of the wings. This species ranges in size from one to one and a half inches and has nearly colorless hind wings.

The lesser migratory grasshopper (Melanoplus mexicanus Sauss.) is about one inch long, reddish brown in color, bears a distinct patch of black on the neck or collar, and is a strong flier.

The red-legged grasshopper (Melanoplus femur-rubrum DeG.) is small, reddish brown above and yellow beneath, with its legs tinged with bright red and its hind wings colorless.

The Carolina grasshopper (Diddodteira carolina L.) is from one and a half to two inches long and is usually of a plain pepper-and-salt color, sometimes varying from gray through yellowish to distinctly reddish brown, depending upon the soil upon which it is found. The species is easily identified in flight by its nearly black hind wings margined with yellow.

The clear-winged grasshopper (Camnula pellucida Scudd.) is small, has clear or pellucid hind wings, and the front wings distinctly blotched with brown. This species is distributed throughout the Northern States.

The life histories of the various species of injurious grasshoppers are similar. The eggs, gummed together to form "pods," are laid in the soil at depths of one to three inches late in the summer or in the fall, usually in grain stubble, meadows, and sod along ditch banks, fences, and roadsides. In the Southern States the eggs may hatch as early as February, but in the Northern States hatching usually does not occur until May or June. The young grasshopper nymphs resemble the mature insects, except that the wings are not fully developed and functional. Although maturity is reached in forty to seventy days, the hoppers may continue to feed until cold weather. There is usually only one generation a year.

During the early nymphal stages the hoppers feed near the place where they hatch and can readily be poisoned at this time. In the later stages they move about in search of food and if numerous may infest the shelterbelts. Considerable migration may occur following the cutting of adjacent fields of hay and small grain. The young shelterbelt strips can be protected during such migration by spreading poisoned bran mash in a barrier from several rods to a hundred feet or more wide around the strips. Several applications at intervals of four or five days may be necessary. During serious outbreaks these barriers will be of no value against migration after the insects have developed to the flying stage.

The poisoned bait is prepared as follows:

Coarse wheat bran (free from shorts or flour)....	100 pounds
Crude arsenic.....	5 pounds
Cane molasses (low grade such as blackstrap.....	1½ gallons
Water.....	10 to 12 gallons

The bran is spread on a tight floor or similar surface, to a depth of eight to ten inches. The required quantities of water, arsenic, and molasses are thoroughly mixed in a container. The solution which should be continually stirred to prevent settling, is gradually splashed over the bran and worked into a mash with a shovel or rake until it contains no lumps and is moist throughout.

A mixture of half bran and half sawdust or, better, three parts bran and two parts sawdust, can be substituted in the foregoing formula, but this mixture is not always so satisfactory as bran alone. Most sawdusts are suitable if fairly fine and a year or more old. Although fresh sawdust from cottonwood can be used, fresh pine sawdust is not suitable. Two quarts of sodium arsenite (four pounds per gallon of material) solution or $2\frac{1}{2}$ pounds of dry sodium arsenite can be substituted also for the five pounds of crude arsenic. Five pounds of paris green can also be substituted, but this is much more expensive. Calcium arsenate, sodium arsenate, or lead arsenate should not be used.

During large control campaigns commercial mixtures for grasshopper control are usually obtainable from certain stock feed mills at a slightly higher cost than the home-made bait. The user has only to add water. The commercial baits should have at least the arsenic content recommended in the home-made formula.

The bait should be spread thinly and evenly at the rate of ten pounds (dry weight) per acre, or more heavily if the insects are very numerous. It should fall into flakes when scattered with the hand, and in this form will be safe for use. If left on the ground in lumps, there is danger that livestock will be poisoned. As the mash dries it becomes less attractive, and it should therefore be applied when the grasshoppers are starting their first feeding of the day, usually early in the morning. The bait should be spread on a clear morning, preferably when the temperature is between 70° and 85° F.

SAP-FEEDING INSECTS

SCALE INSECTS

The scale insects, of the family Coccidae, comprise a group that includes many dangerous tree pests. They are particularly injurious to shade and orchard trees, although they are sometimes dangerous in the forest. Their inconspicuousness, together with the fact that their work is often associated with that of other more conspicuous insects, has resulted in a general underestimation of their economic importance.

The scale insects are peculiar in appearance and at first glance do not appear to be living organisms. Most of them are very small and many appear as tiny scales of wax adhering to the leaves or bark. Others look like small galls, whereas still others appear to be accumulations of granular waxy material or masses of resinous exudations upon the trees. The females are wingless, but the adult males of most species are winged.

The scales can be subdivided into three well defined groups: (1) The armored scales; (2) the tortoise or terrapin scales; and (3) the mealybugs. The armored scales are flat and either oyster-shaped, pear-shaped, or rounded in outline. They cover themselves with scalelike coverings composed of molted skins and waxy secretions of the insect. The tortoise scales are so called because of their tortoiselike form. Some of this group secrete very little wax and are called naked scales, others are naked but have cottony egg sacs, while still others secrete considerable wax. The mealybugs are soft-bodied and oval, and secrete a powdery wax which covers their bodies. This flourlike secretion gives them their common name of "mealybugs."

In connection with the account of each scale insect certain control measures are recommended. While these measures are believed to be reliable, and in the case of highly valued ornamental trees and shrubs can be justified economically, the cost of their application is rather high. In the shelterbelt plantings, in view of the large number of trees planted and the probable low value of the individual trees, their protection by means of expensive spraying programs is economically questionable. Where only one or several limbs are badly infested and are in danger of dying, a preliminary pruning prior to, or in lieu of, a spraying operation might well be undertaken. Such pruned branches should, of course, be destroyed by burning.

Armored Scales

Oyster-Shell Scale
(Lepidosaphes ulmi L.)

The oyster-shell scale was originally imported from Europe but now occurs in practically every state of the Union. It is primarily a sap feeder, often heavily infesting the bark of the limbs and trunks of its host and causing its death. It commonly occurs on apple, but attacks a large number of other plants. It is destructive to many shade and forest trees. Among the more important trees and shrubs attacked are Carolina and lombardy poplar, lilac, horsechestnut, buckeye, ash, cottonwood, willow, apple, dogwood, alder, almond, apricot, arrowwood, beech, birch, boxelder, butternut, cherry, chestnut, elm, hackberry, linden, locust, maple, mountain ash, oak, tuliptree, and Persian walnut.

The oyster-shell scale, as indicated by its name, resembles a miniature oyster shell on the bark of the host plants. The females are light brownish gray to dark brown, varying with the color of the bark to which they are attacked. They are from one-tenth to one-eighth inch in length. The male scales are similar in appearance but smaller. The eggs are pearly white.

This insect passes the winter in the egg stage beneath the female scale. The eggs hatch early in June (in New York,) and the

young nymphs crawl out from under the scales and within a few hours attach themselves to the bark by their beaklike mouth parts. They suck the plant juices and shortly begin forming their waxy coverings. The permanent scales are formed after about six weeks of feeding. By early August most of the females have attained their growth, and egg laying begins. They deposit from forty to a hundred eggs beneath their scales and then shrivel and die. There is but one generation a year.

This scale is perhaps best controlled by dormant oil-emulsion spray. It can also be controlled by dormant spring applications of lime-sulphur at the strength of one gallon to eight gallons of water. In heavy infestations two or three sucessive annual applications may be necessary before the insect is satisfactorily checked.

San Jose Scale
(Aspidiotus perniciosus Comst.)

The San Jose scale is one of the commonest and most destructive pests of shade and fruit trees. It is thought to have been imported from China in 1870, and now occurs in practically every State in the Union. It has a large number of food plants, which make control measures difficult. Some of the more important shade and shelterbelt trees subject to attack by this insect are Osage orange, wild plum, ash, mountain ash, catalpa, cherry, elm, hackberry, locust, maple, mulberry, poplar, black walnut, willow, and pecan.

The female scales are nearly circular, slightly convex, almost black when small and gray when fully developed, with a central yellow or orange nipplelike structure formed from the shed skin. They are about one-sixteenth inch in diameter. The bodies are bright yellow with two pairs of lobes. The male scales are of the same color, but narrower and smaller. The adult males are minute, pink, two-winged insects.

The partly grown insects pass the winter beneath tiny black scales on the bark. In the spring they resume feeding and reach maturity in May and June. The females bear living young, sometimes as many as two hundred to six hundred over a period of six weeks. The tiny yellow insects crawl over the tree, and in a few hours each one settles down, inserts its beak, and begins secreting white waxy threads, which in two or three days form a circular grayish scale. From three to five generations are produced annually, varying with the latitude and climatic conditions.

Lime-sulphur, at dilutions of one gallon to eight gallons of water when it tests 32° to 33° by the Baume hydrometer, applied late in the spring before the buds burst, is safe and effective. Oil emulsions have also been used with considerable success. They should be applied in early spring before the buds burst but when the temperature is 40° F. or above. Oil emulsions may damage some trees, especially maple.

Putnam's Scale
(Aspidiotus ancylus Putn.)

Putnam's scale so closely resembles the San Jose scale that it is frequently mistaken for it. It is not nearly so destructive, however. It occurs over the greater part of the United States on a wide variety of host trees. Soft maple and linden are most susceptible, but it also attacks ash, elm, hackberry, locust, and a number of other trees and shrubs.

The female scales are about the same shape as the San Jose scale, about one-twelfth inch in diameter, but they are a little darker and the nipplelike structure is brick red and a little to one side instead of being in the center. The male scales are smaller, elongate, and have the nipple at one side.

The winter is passed in the partly grown stage. The fragile, winged males appear in April or May, depending on the temperature, and the females deposit from thirty to forty eggs under the shelter of the scale in early summer. The young hatch before midsummer, fasten themselves upon the bark, and form their scale coverings. There is but one generation a year.

Where artificial control is necessary, this insect can be successfully combated by spraying the infested trees or shrubs with a soluble or miscible oil or oil emulsion diluted according to the manufacturer's recommendations and applied in the spring before the buds break. With all scale insects thoroughness of application is essential to successful control.

Walnut Scale
(Aspidiotus juglans-regiae Comst.)

The walnut scale is distributed widely over the United States. Although it has been reported as killing trees, it ordinarily kills only individual limbs, and is not a serious pest. The walnut scale is not confined to Persian walnut trees, but it infests chiefly cottonwood, and attacks ash, boxelder, elm, linden, locust, maple, and many fruit trees.

The female scale is flat, nearly circular, pale gray or yellowish, and one-eighth inch in diameter, being larger than other similar scales. The body of the female is yellow mottled with orange. The young scales have a habit of clustering about the mother in regular formation, frequently forming a circle. The male scale is smaller and elongated.

These scales overwinter as adults, the female laying eggs early in the spring. The eggs soon hatch, and by June this brood has matured and the eggs for another brood have been deposited. There are at least two generations annually.

Thorough spraying with the standard lime-sulphur solution, one gallon to eight gallons of water, before the buds open in the spring will check the damage of this scale. Applications of miscible oils according to the manufacturer's directions will also control the scale on most host plants, but dormant strength oils should probably not be used on maple or black walnut, because of the danger of injuring these trees.

Pine Needle Scale
(Chionaspis pinifoliae Fitch)

The pine needle scale is a native insect which attacks the needles of pines, firs, and spruces throughout most of the United States. Where very abundant these scales materially weaken the trees, making them more susceptible to attack by other insects, but they are also capable of killing trees outright. It attacks particularly ponderosa, digger, sugar, white, lodgepole, Monterey, Torrey, red, Scotch, and Austrian pines. It also attacks Douglas fir, white fir, and spruce.

The mature female scale is white, one-tenth inch in length, flat, and either narrow or rounded, depending on the shape of the needle to which it is attached. The male scale is also white but smaller, being one-twenty-fifth inch in length, elongated and narrow.

This scale overwinters in the egg stage. The eggs are reddish, and thirty to fifty of them occur beneath one scale. They are laid in the fall and hatch early the following summer. If temperatures are low, the young nymphs remain beneath the scales until warmer days occur and then migrate outward and settle on the needles. In warm regions there are two generations a year, but in the north there is but one generation.

When the nymphs are small they can usually be controlled by two applications of 40% nicotine sulphate, one part to 500 parts of water, to which about ½ of one per cent of soap flakes or liquid soap (four pounds to 100 gallons of solution) is added. Lime-sulphur spray, one part to seven parts of water, may also be used. A 2% summer white-oil emulsion may be used on pine, but it should not be used on spruce. These sprays should be applied at the time of hatching.

Elm Scurfy Scale
(Chionaspis americana Johns.)

This scale is distributed from Massachusetts to Minnesota, Kansas, and Texas. It is often found on American elm, and it also occurs on the Camperdown elm and the pendula variety of the American elm. At times it becomes abundant enough to kill the smaller branches and cause the trees to appear ragged. In serious infestations it may kill young trees outright. The females are confined to the bark and may be found over the trunk, limbs, and smaller branches.

The pear-shaped female scale measures from one-twelfth to one-eighth inch in length, and is white, gray, or sometimes yellowish, but often blackened by sooty mold. When removed from the bark a conspicuous white mark remains. The male is narrow and white, with parallel sides. It is scarcely one-twenty-fifth inch in length. The male scales may be found both on the bark and on the underside of the leaves.

The insect passes the winter in the egg stage beneath the scales of the female. The eggs are purplish and occur in groups of twenty to seventy. They hatch in the spring. There are probably two generations a year.

A nicotine sulphate spray applied soon after the eggs hatch, probably early in June, should control this scale, and dormant-strength oil-emulsion or miscible oil applied during the dormant season, preferably in spring, should give good control.

Scurfy Scale
(Chionaspis furfura Fitch)

The scurfy scale is a native species that may infest black walnut, elm, hawthorn, horsechestnut, mountain ash, white ash, willow, and other trees. It is widely distributed in the East from Canada to Georgia and westward to Kansas, Idaho, and Utah. When the scale is abundant, it coats the branches, giving the bark a grayish or scurfy look. The tiny insects suck sap and weaken the trees.

The female scale is a dirty gray color and pear-shaped. The male is smaller, snowy white, and long and narrow.

Like many of the other scale insects, this species passes the winter as purplish-red eggs beneath the scale of the female. The eggs hatch in early summer, and the young settle down on the bark, insert their beaks, and feed. They soon become covered with the white scales, which are formed from a waxy secretion. By early fall the females complete their growth, lay their eggs, and die. In the Northern States there is usually but one generation, but in the South there are at least two complete generations.

The control for this pest consists in the use of an oil spray or lime-sulphur at dormant strength in the spring before the buds open.

Willow Scale
(Chionaspis salicis-nigrae Walsh)

This common willow scale is widely distributed over the United States from the Atlantic to the Pacific coast. The twigs, branches, and trunk of the host are attacked, occasionally with such severity as to cause death of parts of, or the whole tree. It prefers willows but also attacks alder, maple, poplar, tuliptree, dogwood, and shadblow.

This is the largest of the scurfy scales, measuring from one-tenth to one-sixth inch in length. The female scale is often pear-shaped, always broadest near the middle, and is white. The male scale is long and narrow and snow white.

This insect overwinters as purple eggs beneath the scale of the female. The eggs hatch in the spring and mature in about two months. In Colorado there are two generations each year.

The safest material to use against the willow scale is lime-sulphur. It should be applied as late in the spring as possible, just before the buds burst. Dormant-strength lime-sulphur, one gallon to eight gallons of water, should be used. Follow-up applications should be made for two or three seasons to clean up an infestation.

Tortoise Scales

Pine Tortoise Scale
(Toumeyella numismaticum Pettit and McD.)

The pine tortoise scale is a serious pest of jack pine and Scotch pine. Heavy infestations many result in the death of many trees and seriously weaken others. This scale has been reported from Michigan, Wisconsin, Minnesota, and Nebraska. Infested trees may be detected by their coal-black appearance, caused by a sooty fungus growth which establishes itself on the honeydew produced by the insect.

The scales have the appearance of miniature tortoise shells on the infested twigs among the needle bases. They are comparatively large and soft, convex, rounded, and reddish brown.

The females overwinter in the half-grown stage in Nebraska. The males emerge from their white cocoons in the fall. Eggs are laid in the spring and the nymphs (crawlers) appear in early June. There is but one generation a year.

Cutting out infested trees has been practiced in an attempt to eradicate this scale from a small area in the Nebraska National Forest. A spray of 2% summer white-oil emulsion, applied while the crawlers were present gave fair control, with no noticeable injury to the trees. A 2% miscible oil applied before the growth appears in the spring is reported as giving successful control in Wisconsin.

Cottony Maple Scale
(Pulvinaria vitis L.)

The cottony maple scale is among the most conspicuous of the group and on occasion may be considered among the most destructive.

It is noted for its sudden appearance in great numbers in a given locality. It is a native insect and occurs throughout most of the United States. It appears to prefer silver maple and basswood, but also occurs on the Norway maple, sugar maple, boxelder, alder, beech, buckeye, elm, hackberry, hawthorn, linden, locust, honey locust, mountain ash, mulberry, oak, Osage orange, sycamore, willow, and many fruit trees.

The scale is of the unarmored, soft type and a rather large species. When mature the females are one-quarter inch long, convex, and brown. When the large cottony egg sacs are formed, the scales become very conspicuous, and they are most easily noticed at this time. The eggs are reddish yellow and are contained within the sacs. There is but one generation a year.

The fertilized immature females overwinter on the twigs. They mature early in the spring and lay their eggs in May in the latitude of Washington, D. C. They hatch in late May or early June, and the active young nymphs settle on the leaves. Fertilization occurs in August, and the immature females migrate to the twigs.

The use of the safer miscible oils in the spring before the buds open will undoubtedly control this pest. They should be used as directed, usually one part to fifteen parts of water. Maple are susceptible to injury by oils, and care should be taken in applying the heavier oils to these trees. Summer spraying with nicotine sulphate, one part to 800 parts of water in which some soap has been dissolved, will also control this scale if the young are reached.

European Fruit Lecanium
(Lecanium corni Bouche)

This imported European scale now occurs over the entire United States. It is considered the commonest and most injurious member of the genus. Besides many of the fruit trees it attacks oak, ash, linden, beech, boxelder, chestnut, elm, locust, magnolia, poplar, willow, butternut, hickory, walnut, maple, and others. The insects feed on the leaves and twigs, killing them when abundant.

This insect is found in a variety of shapes, sizes, and colors. The typical form is almost hemispherical, slightly longer than broad, smooth, of a shiny brown color, and from one-eight to one-fifth inch long. They are often crowded on the undersides of small twigs so that they overlap. The male scale is delicate, whitish, nearly transparent, flat, thin, and much longer than wide.

The females overwinter in the partly grown stage on the twigs of the previous year's growth. They mature in early summer (May in New York) and lay large numbers of white eggs. Hatching proceeds for about two months, and the young migrate to the leaves, where they settle on the undersides along the midribs and veins. In late summer they migrate back to the twigs. There is but one generation a year.

Control consists in the application of oil emulsion or miscible oil during the winter months, when temperatures remain above freezing for a day or more. Miscible oils, one part to fifteen parts of water, applied late in the spring just before the buds open, give good results.

Mealybugs

European Elm Scale
(Gossyparia spuria Mod.)

The European elm scale is an introduced pest which has become widespread over the entire United States. It has been especially severe in this country because, like most imported insects, here it is free of most of its natural enemies. This scale attacks all species of elms, especially American elm, European elms, slippery elm, and corkbark elm. It attacks the trunks and limbs, killing small and large branches, and even young trees. Older trees are seldom killed but are often much weakened.

The adult females are readily recognized by the white, cottony fringes or rings around the oval, dark reddish-brown bodies, which are about one-twelfth inch long. They are often crowded on the bark so thickly as to be very conspicuous. The young are covered with a thick, powdery wax, giving them the appearance of "mealybugs." The males are very small and of two forms, the winged and the wingless.

The insect overwinters as second-stage, gray oval nymphs in crevices of bark. They reach maturity early in the spring, and the females lay their eggs, from which the young hatch late in June in the latitude of Ohio. They settle on the leaves and suck out the juices, but during late August and September the young migrate from the leaves and settle in crevices of the bark. Some fall with the leaves and die, while others are blown with the leaves and probably crawl up and infest other trees. This scale is single-brooded, but it is exceedingly prolific and is a severe pest of many species of elm trees.

Control measures consist in the application of miscible, distillate, or crude oil sprays while the trees are dormant by means of power spraying outfits. Early in the spring before the buds break, the application of a miscible oil, one gallon to fifteen gallons of water, will give good control. Water under high pressure will wash the insects from small trees, but the use of oil sprays is more satisfactory.

APHIDS

Because of the vast number of species of aphids and their power of rapid multiplication, they have an economic importance almost as

great as the scale insects. Aphids are injurious to all forms of plant life and may be found on the bark, leaves, blossoms, fruit, and roots. Most of them cause no hypertrophies on the host by their feeding; however, some produce large, warty outgrowths on the bark, while others produce curling or pseudogalls and true galls on the foliage. In feeding they extract the juices from the plant tissues, and this results in the abnormalities already mentioned and in the drying up and weakening of the whole plant. Many aphids are also responsible for disseminating fungi and other plant diseases. Most species excrete honeydew over the host plants, which is eaten by flies, ants, and bees.

Although aphids vary considerably within the group, the general characters are so constant that they are easily recognized. They are small, delicate, soft-bodied creatures, often green or dark in color, and wingless or winged. Certain species are coated with a white, cottony wax, and are known as woolly aphids. When wings are present, they are two-paired, light, membranous, and in most species meet roof-shaped over the body when at rest.

Aphids are rather sluggish insects, usually resting on one spot on the host plant, where the mouth parts are inserted, but when disturbed or seeking better feeding places they withdraw their mouth parts and move about. Most species feed in colonies, often completely covering a portion of the host. The winter is passed in the adult, nymph, or egg stage, usually on some host plant. In the spring the eggs hatch into stem mothers, which are wingless and capable of producing living young without being fertilized. Reproduction is rapid and enormous numbers may result from a single female during one season. There are usually many generations annually.

Some of the aphids that affect trees planted in the Great Plains States are as follows: The elm leaf aphid (Tuberculatus ulmifolii Morell); the woolly elm aphid (Eriosoma americanum Riley); the elm cockscomb gall (Colopha ulmicolo Fitch); the bolelder aphid (Periphyllus negundinis Thos.); the ash aphid (Pemphigus fraxinifolii Riley); the petiole leaf gall (Pemphigus populicaulis Fitch), on poplars; the leaf stem gall (Pemphigus populitransversus Riley), on cottonwood; and the vagabond gall (Mordwilkoja vagabunda Walsh), on cottonwood.

Aphids are readily controlled by spraying with a contact insecticide. These sprays should be applied as soon as the aphids appear, to prevent the building up of a large population. A nicotine spray may be prepared by mixing one pint of 40% nicotine sulphate, three to five pounds of fish-oil soap or soap flakes, and enough water to make 100 gallons. An oil spray consisting of one gallon of miscible oil, seven pounds of fish-oil soap, and sufficient water to make 100 gallons, should also be effective, Pyrethrum and derris compounds have also been used successfully against these insects. The directions for aphid control given on the container of the insecticide, should be followed.

RED SPIDERS OR MITES

There are several species of red spiders, or mites, that attack various evergreens and hardwoods. Although they are not true insects, being more closely related to the spiders, they are included here because control measures used against mites are similar to those used against certain insects. The mites have four pairs of legs and are very small, the immature forms of some species being so small that they cannot be seen with the naked eye. The injury to the host is usually noticed before the mites are seen. They suck the juices of the plant and cause the leaves to turn yellow or brown, and often to fall. Over a period of years the mites may kill the host or severely weaken it and make it susceptible to borer attack.

The common red spider (Tetranychus telarius L.) is very widely spread and attacks a number of plants, including evergreens, hardwoods, and herbaceous plants. Individuals vary in color from brick red to green or yellow. The winter is passed in cracks in the soil or beneath clods and objects on the ground. They become active with the coming of warm weather in the spring and lay their sperical, yellowish eggs on the leaves of the host plants. One generation is completed in two weeks and by midsummer they are very abundant.

The spruce mite (Paratetranychus uniunguis Jacobi) attacks spruce and possible other conifers. The species passes the winter in the egg stage on the small branches of the host. These reddish spherical eggs hatch in the spring into light green mites. About seventeen days is required for the development of one generation. The foliage of infested trees is covered with very fine silk. The lower branches lose their needles and die first.

There are many other species of mites, such as Eriophyes ulmi Garm., which attacks elm, and Eriophyes fraxiniflora Felt, which attacks the flowers of ash, and some species that cause galls to form on the small branches.

Mites are more difficult to control than some insects. Some of the common recommendations are as follows:

Dissolve one to one and a half pounds of glue in ten gallons of water and spray on the foliage. The glue should first be dissolved in hot water and then strained to take out the lumps. It may be necessary to make several applications of complete control.

Summer white oil applied at a dilution recommended on the container is effective against the young mites. Since this insecticide does not kill the eggs, it may be necessary to make three applications at weekly intervals. This material should not be used on spruce, as there is danger of burning the foliage.

Commercial lime sulphur applied at the recommended summer strength and a finely divided sulphur applied as a dust are also effective.